



**University of
Reading**

**Understanding resilience to climate variability and change in common bean
smallholder farming in Malawi: A gender-based perspective**

By

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ABSTRACT

Smallholder farmers dominate Sub-Saharan African (SSA) agriculture which serves as a mainstay to their respective countries' economies. Of the smallholder farmers in the SSA, females constitute a larger proportion in provision of labour force in smallholder farming system. Hence, gender issues at every stage of production activities are crucial. Smallholder farmers' agricultural production in Sub-Saharan Africa is largely characterised by subsistence farming and production under unfavourable conditions, such as low and erratic rainfall and poor soils that exacerbate non-climate stressors. As a result of unfavourable conditions, yields of key crops and livestock health are reduced, directly or indirectly affecting the livelihoods of smallholder farmers. It is widely conceded that farmers' perceptions of the changing climate influence the way they take action to counteract risks and/or exploit the opportunities induced by the changing climate. In smallholder farming, climate change actions include decisions on the use of adaptation strategies, and changes in production activities. Considering that the barriers to adaptation to climate change are prevalent across multiple actors, including individuals, groups and institutions, there are variations on who makes decisions on coping and adaptation strategies in smallholder farming. Such actions help build the resilience of farmers to the impacts of the changing climate. However, in Malawi, where smallholder farmers are heavily affected by the impacts of climate variability and change, quantitative evidence of the relationship between perception, decision making and direct involvement in bean production activities, and farmers' resilience to the changing climate in smallholder farming, is scant. The main objective of this study was to understand farmers' resilience to the changing climate based on their perceptions, decision-making and involvement in bean production activities, including gender and the extent to which this relationship contributes to food self-sufficiency, security and income in smallholder farming in Malawi.

The research was conducted in four districts: Dedza in the central region, and Chikwawa, Nsanje and Zomba in the southern region of Malawi. The study employed a multi-stage sampling technique to select Extension Planning Areas (EPAs), sections, villages and households where cross-sectional data was collected from 356 farm households. In addition, a purposive sampling procedure was used to select study subjects for focus group discussions (FGDs), trend analysis, and pair-wise ranking. Econometric analysis suggests that farmers' experience in bean farming, group membership, literacy levels, gender, and land holding size are among the factors influencing farmers' perceptions of the changing climate. Similarly, age

of household head, and large acreage reduces the level of effects of droughts or dry spells, and severity of pests and diseases respectively on bean production in smallholder farming. These results suggest that older farmers, who are more experienced, have learnt how to respond to climatic shocks, and that smallholder farmers are at higher risk of biotic stresses, i.e., pest and diseases.

The study also examined decision-making and direct involvement in bean production activities in smallholder farming in the face of climate variability and change. Empirical results suggest that there is an overlap in some of the factors that influence decision-making and direct involvement in bean production activities. Decision-making on bean farming activities that attract more physical effort are normally made by household heads in both male and female-headed households. However, males dominate the participation in decision-making on bean farming activities than females. Furthermore, decisions on critical bean farming activities are made by household heads with dominance by males. By contrast, direct involvement in performing bean farming activities is not significant for many activities, however, females dominate some bean activities and are significant. This suggests dominance in provision of labour force by females, and lack of participation in decision making in bean farming.

Other findings are that age has a negative relationship with (access to basic services) ABS and stability (S), and a positive relationship with adaptive capacity (AC). Further, group membership has a negative influence on ABS and IFA, and a positive relationship with AC and S. Literacy influences ABS, AC, and S positively, and income and food access (IFA) negatively. This result implies that age, group membership, and literacy are crucial factors influencing resilience in smallholder farming. The results also revealed differing resilience across the study districts of Dedza, Chikwawa, Nsanje, and Zomba. These results suggest that policy interventions aimed at addressing vulnerabilities as they emerge in particular geographical locations need to be supported.

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PLAGIARISM DECLARATION

I, Kelvin Dambuleni declare that:

1. The work presented in this thesis, is my own original research, except where otherwise indicated.
2. This thesis, or any part of it, has not been previously submitted by me or any other person for any degree or examination at any other University.
3. This thesis, all materials and sources used in its preparation, whether they be books, articles, reports, lecture notes, and any other kind of document, electronic or personal communication are duly acknowledged, and the sources cited are identified in the thesis references.
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Signed: _____ Date: 24/11/2021
Kelvin Dambuleni

We hereby agree to the submission of this thesis for examination

Signed: _____ Date: 24/11/2021
Associate Professor. Sarah Cardey (Supervisor)

Signed: _____ Date: 24/11/2021
Professor. Kelvin Balcombe (Co-supervisor)

DEDICATION

I dedicate this thesis to my mother and in loving memory of my father.

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LIST OF ACRONYMS

ABS	Access to basic services
AC	Adaptive capacity
APT	Agricultural practice and technology
CRI	Climate resilience index
CSA	Climate smart agriculture
DADO	District agriculture development officer
DFID	Department for International Development
DDS	Dietary diversity score
DHS	Demographic and health survey
DoCCMS	Department of climate change and meteorological services
EIE	Enabling institution environment
EPA	Extension planning area
FAO	Food and agriculture organization
FGD	Focus group discussion
GDP	Gross domestic product
GHG	Greenhouse gases
GLM	General linear model
GoM	Government of Malawi
HFIAS	Household food insecurity access score
IFA	Income and food access
ILO	International labour organization
IPCC	Inter-governmental panel on climate change
KMO	Kaiser Meyer Olkin
LR	Likelihood ratio

LSMS-ISA	The living standard measurement study integrated surveys on agriculture
MCCCI	Malawi Confederation Chambers of Commerce and Industry
MEGS	Malawi economic growth strategy
MK	Malawian kwacha (currency)
OECD	Organisation for economic co-operation and development
OLR	Ordered logistic regression
OLS	Ordinary least squares
PC	Principal component
PCA	Principal component analysis
S	Stability
SDG	Sustainable development goals
SEM	Structural equation modelling
SES	Social ecological system
SNF	Symbiotic nitrogen fixation
SSA	Sub-Saharan Africa
SSN	Social safety net
UNICEF	United nations international children's emergency fund

CHAPTER 1. INTRODUCTION

1.1 Background

Economies of most of the sub-Saharan African (SSA) countries depend on agriculture for development due to their larger contribution to the overall economy. A majority of the population in SSA directly or indirectly depend on agriculture for their living and live in rural areas where poverty and deprivation are most severe (Diao *et al.*, 2010). More than a half of that population is employed in the agricultural sector, where the labour force remains stuck in subsistence production and low productivity (Shimeles, Abebe (Ed.); Verdier-Chouchane, Audrey (Ed.); Boly, 2018), and contributes about 23 percent of the total gross domestic product (GDP) (Goedde *et al.*, 2019). In Malawi, the agricultural sector continues to be the most important sector in her economy. In the 2004 Malawi Economic Growth Strategy (MEGS), agriculture is stated to account for 39 percent of the GDP, 85 percent of the labour force and 83 percent of foreign exchange earnings. In 2010, the Malawi Confederation of Chambers of Commerce and Industry (MCCCI) stated that agriculture is the mainstay of Malawi's economy, contributing about 33.6 percent to the economic growth. The GDP originating from agriculture is at least twice as effective in reducing poverty as GDP growth originating from outside agriculture because it impacts upon the mainstream of the mostly poor section of the population, and the sector supports 82 percent of the rural population in Malawi (Mucavele, 2013). Amongst the crops with the greatest potential to enhance food security and poverty reduction are common beans, which are primarily grown by smallholder farmers in Malawi. Smallholder farmers enjoy its capacity as a leguminous crop which fixes the atmospheric nitrogen, thereby contributing to soil fertility improvements. Beans also serve as an important source of nutrition in Malawi, providing dietary fibre, minerals, much-needed protein in a diet dominated by maize, and are second only to maize as a food crop (Chirwa, 2006; Fan & Beta, 2016; Njuki *et al.*, 2011; Scott & Maiden, 1998). In the major bean growing areas, the main objective of production is for markets contributing to household income, and has proven to be the most commercially viable crop with greatest potential to sustainably reduce poverty; however, some small proportion of the production is used for household consumption (CIAT, 2013)

Despite the importance of beans in Malawian smallholder farming, its production is threatened by unfavourable conditions characterised by higher temperature, droughts, low and erratic

rainfall, floods or excess rainfall, pests and diseases, hailstorms and poor soils due to the changing climate and interaction with other non-climatic stressors (Maganga & Malakini, 2015; Mendelsohn *et al.*, 2006; Vásquez-León *et al.*, 2003). As a result of such unfavourable conditions, smallholder farm households' yields of specific food and cash crops, productivity, and health of livestock are undermined, which directly or indirectly affects their livelihoods (Morton, 2007).

Considering the critical role of agriculture in most SSA economies, including Malawi, and that rain-fed farming dominates agricultural production, smallholders in SSA will have to gradually adapt and adopt technologies that increase the productivity, stability, adaptive capacity, and the resilience of production systems (FAO, 2008). Other factors affecting productivity include changes in temperature, carbon dioxide fertilization, surface water run-off, and climate variability (World Bank, 2008). In order for smallholder farmers to adopt technologies to counteract the impacts of climate change, their positive perception and engagement is a necessary prerequisite (Gadédjisso-tossou, 2015). Adaptation to the changing climate follows a two-step process; firstly, to accept there is a change and, secondly, making decisions to adapt or adopt (Maddison, 2007). Perception of climate change is an immensely challenging idea for the farmers and has limited confines as individual's perception differs with their past and present situations (Saarinen, 1976). Farmers who perceive climate change based on affective impression and direct personal experience are more likely to suffer cognitive bias in their perceptions, compared to farmers who perceive climate risk based on knowledge and analytical processing of climate information (Hitayezu *et al.*, 2017). Farmers' perceptions, knowledge, attitudes and practices of climate variability and change are key to designing climate change adaptation programmes. Moreover, strategies that better provide insights and generate information relevant to policy interventions contribute to a higher adoption rate of climate change adaptation strategies (Munthali *et al.*, 2016).

Decisions and direct involvement of farmers on production activities in implementing climate change adaptation strategies at farm level rely on their perception of changing climate. Household decision-making determines many choices with important consequences including the distribution of income, allocation of time and resources (Doss, 1996; Doss, 2013; Quisumbing and Maluccio, 2003). Adger *et al.* (2009) stated that barriers to adaptation to climate change are prevalent across multiple actors, including individual groups, and institutions, and therefore it is important to understand how decisions are made to adapt to

climate variability and change within the households. There are variations in who makes coping and adaptation decisions to climate variability and change within the households. Household coping and adaptation practices are gendered and therefore, adaptation adjustments in farming households occur within existing gender roles. Men and women may take decisions on certain coping and adaptation practices but not others, implying that the kinds of coping or adaptation practices also determine who makes decisions (Bomuhangi *et al.*, 2016). Climate adaptation decisions are not undertaken in a stand-alone fashion but rather within the prevailing societal norms and cultural practices (Neil Adger, 2013). In areas where strong cultural and social systems describe the roles of men and women, more often than not more power is ascribed to men when it comes to the decision-making process (Shero, 2014). Men commonly make decisions on coping and adaptation practices that are associated with financial resources such as selling-off assets for adaptation or financial or non-financial assistance, and would spend cash-savings primarily to purchase food or invest production activities (Bomuhangi *et al.*, 2016). Bomuhangi further argued that women are less likely to make decisions alone; their decision-making processes are largely consultative in nature. In a bid to address the effects of climate change in order to enhance adaptive capacity at farm household level, the gender dimension of decision-making has to be recognized as gender inequality in household decision-making affects the well-being of men, women, and children within the household (Quisumbing and Maluccio, 2003).

Smallholder farmers' production activities are heavily affected by the effects of climate variability and change such as droughts, floods and rising temperature. In many cases when these climatic shocks occur, livelihoods of smallholder farmers become threatened, in which case, adaptive capacity, reduced exposure, and sensitivity to climate shocks among smallholder farmers would help reduce vulnerability and increase their resilience. Enhancing the resilience of smallholder farmers to climate shocks is important in strengthening the performance of smallholder farming systems. Alongside the main components of resilience (income and food access, assets, stability, social safety nets, adaptive capacity, and access to basic services), other factors which may not directly be involved in building resilience can be used to explain it (Alinovi, Mane, *et al.*, 2010). These factors include the farmers' ability in gaining experiences from failures and harnessing new opportunities, perceptions of farming risks and impacts, and confidence in financial capacity, as well as income from diversification activities, which can be used to invest in farming. In addition, enabling institutional environment (EIE) explains households' resilience due to their reliance on government, other private actors, and the

presence of strong support from local and central authorities, i.e., rural communities' perception of the presence and quality of services provided to cope with shocks. Finally, agricultural practice and technology (APT) explains household resilience through the use or non-use of different technological innovations at farming level, i.e., fertilizers, artificial insemination, crop varieties, water and soil conservation measures, irrigation systems, crop husbandry practices, and other technological inputs adopted in agricultural practices (Hang *et al.*, 2016).

1.2 Problem statement and justification

Smallholder farmers are among the most significant populations expected to be highly affected by the impacts of climate change due to their dependence on rain-fed agriculture (Morton, 2007). Importantly, smallholders form a vital part of the global agricultural community and manage over 80 percent of the world's estimated 500 million small farms and provide over 80 percent of the food consumed in a large part of the developing world, contributing significantly to poverty reduction and food security (IFAD & UNEP, 2013). In Africa, agriculture represents a major economic activity and, on average, contributes 15 percent of GDP, though this varies widely across the continent (OECD-FAO, 2016). It is, therefore, believed that agriculture in Africa has the potential to contribute to eradicating poverty and hunger, by boosting agricultural investment and trade, creating jobs, and improving livelihoods (NEPAD, 2013). In SSA, approximately 33 million smallholder farmers represent 80 percent of all farms in the region and contribute up to 90 percent of food production in some SSA countries (Wiggins & Keats, 2013). In Malawi, agriculture defines the face and direction of overall economic growth. For instance, in 1991, 1993, 1995 and 2005, where growth in agriculture slumped, subsequent periods of exceptional drought markedly reduced growth in the overall GDP, which shows clearly that there is a close correlation between agricultural sector performance and overall economic performance. However, Malawi's agricultural sector is dominated by smallholder farmers who comprise over 90 percent of the sector and operate under a low-input rain-fed system. Therefore, performance of smallholder farmers dictates the performance of the country's economy (Tchale, 2009).

Historically, considerable growth in their agricultural sectors led to an initial boost in most advanced economies, suggesting the potential for an important role in the economic development of most of the developing countries (Diao *et al.*, 2007). However, despite the

importance of smallholder farmers in the agricultural sector, they are characterized by low revenues, and socio-economic features, land size, resource endowments, regions and countries which are associated with activities which together form a livelihood strategy where the main output is consumed directly. Further, they produce using low input and only a minor proportion of output is marketed. The majority of labour is provided by the family and normally have low asset base, operating in less than 2 hectares of cropland and with limited resource endowments (J. Dixon et al., 2004; Narayanan & Gulati, 2002). Many smallholder farmers in Africa, including Malawi, are women whose activities are characterized by gender gaps regarding access to, and control of, key resources such as land, labour, credit, information, extension, and technology. As a result, women and men farmers in developing countries have different abilities to adapt to climate change (Huyer, 2016). However, irrespective of these gender gaps, women are important agents of innovations in response to climate-induced change. Their resilience strategies and local environmental knowledge are valuable resources for recovery and adaptation (Denton, 2002a). The growing empirical evidence supports the broad view that women's lower access to assets, services, and voice makes them more vulnerable than men to the effects of natural disasters and climate change, thereby rendering them less resilient. Women tend to be more vulnerable because their roles and needs are underestimated or neglected in planning and action, even though they are key labour force for most production and development activities (Resurreccion, 2011). Again, women have greater sensitivity to climate change and natural disasters than men due to their lower levels of access to critical resources (Alber, 2011; Oxfam, 2009). Building resilience to changing climate requires not only preparation for coping with shocks and stresses associated with climate change, but also engaging with gender issues and women's empowerment to reduce particular vulnerabilities (Oxfam, 2009). It is, therefore, essential to have gender-sensitive strategies for strengthening the resilience of at-risk or affected communities against climate change impacts (UNWomenWatch, 2009).

Recent research has started to advocate catalysing women and vulnerable groups to increase their control over productive assets and resources plus increasing participation in decision-making at local and national levels. However, there continues to be limited knowledge of how social and gender disparities affect the ways in which poor men and women respond to the impacts of climate change on agriculture. Therefore, there is a need to explore mutually reinforcing resources between men and women who control assets, promoting more equitable decision-making in order to balance gender relations. In addition, agricultural production needs

to be sustainably increased to support smallholder farm households' resilience to climate variability and change (Huyer, 2016).

As a concept, resilience has a wide range of meanings and definitions which comprise two main variants. One is engineering resilience where the main focus is efficiency, constancy, and predictability. The other is ecological resilience which has been particularly influential, and focused on the capacity of the system to absorb changes but still maintain its core functions (Nguyen & James, 2013). The more recent conceptualizations of resilience mostly with regard to human systems give greater recognition to the potential needs of a system to adapt and change its core structures and functions, with some cases requiring transformation (Aldunce *et al.*, 2015). Therefore, the resilience of a human system can be thought to comprise a range of different capacities and components, including households' ability to prepare and to recover. Key elements include anticipating and reducing the impact of climate variability and extremes through preparedness and planning, often by making use of relevant information and early warning (Bahadur *et al.*, 2015). This is associated primarily with a household's ability to absorb and cope with the impacts of climate variability and extremes, often through maintaining core functions or livelihood activities (Folke *et al.*, 2010); and its ability to adapt – more specifically, to adjust, modify or change its characteristics or actions to moderate potential damage or take advantage of new opportunities that arise. Based on different definitions of resilience cited in literature, this study recognises the importance of each definition. However, this study defines resilience as perseverance of individual farmers, communities, or institutions/systems to the impacts/effects of climate variability and change through access to resources and information to still function relatively the same as before the disturbance as a result of the varying and changing climate.

In Malawi, recent research by Mulwa *et al.* (2017) has raised the importance of looking at farmers' responses to climate risks, due to the fact that it plays a major role in establishing why smallholder farmers fail to adopt what appear to be relatively simple agronomic or management practices which can help them cope with climate-induced stressors. Their study specifically concentrated on the type of practices that smallholder farmers had adopted in recent years to cope with recently observed changes in weather patterns. The study results showed that farmers had changed to planting drought-tolerant varieties, adopted early planting, switched to pest- and disease-tolerant varieties due to increased disease and pest pressures and crop

diversification. However, given the rapidly changing climate, their ability to respond effectively to increasing incidences of shocks needs to be strengthened beyond adaptation. Thus, building resilience and adaptive capacity is essential for addressing the challenges faced by the households as a result of changing climate because resilient households are more likely to anticipate, resist, cope with and recover from shocks (Fan *et al.*, 2014). Furthermore, a crucial dimension of climate change mitigation and adaptation is to see if it has a differentiated effect on male and female farmers and also evaluating their decision-making choices of coping or adaptation strategies.

Recent research by Tambo (2016) used indicators to measure farm households' resilience through the construction of the climate resilience index by identifying key socio-economic variables and other capitals that support people's livelihoods. Despite such approaches having operational benefits, it is extremely difficult to identify all the relevant traits and indicators – from economic to socio-cultural and political factors – that influence a household or community's resilience (Cutter *et al.*, 2008). Furthermore, identification of key socio-economic variables typically requires large and robust socio-economic datasets, which are not easily found in developing country contexts. In view of this, the use of subjective approaches to understand farm household resilience can add value to and complement objective forms of approaches. Subjective resilience stems from the premise that people have good understanding of their own capacities and limits. In leveraging more bottom-up processes of data collection, 'subjective' indicators of perceived resilience are based on behaviours, attitudes, and psychology: factors not easily captured by traditional 'objective' indicators. The measurement of perceived resilience, therefore, is about how people rate their own resilience, and the resilience of the wider community of which they form part (Jones & Tanner, 2015).

This research, therefore, used both subjective and objective approaches to understand resilience through exploring farmers' perception, knowledge, and decision-making and direct involvement in bean production activities in smallholder farming. Further, this research used a gender-based dimension approach at every stage of assessment in order to understand the gender dynamics beyond a simplistic differentiation of male-headed and female-headed farm households. The idea is to capture how production decisions are made in relation to the changing climate. This research will help generate evidence to inform development practitioners, researchers and decision makers of the components of smallholder farm households' resilience which are critical and require attention to their systems' resilience. This

research will also help reveal areas of improvement in the already existing technologies geared towards helping smallholder farm households' resilience to climate variability and change in the context of gender.

1.3 Study objectives and research questions

This study aims to understand farmers resilience to changing climate based on their perceptions, decision-making and involvement in bean production activities, gender consideration and the extent to which this relationship contributes to food self-sufficiency, security and income in smallholder farming in Malawi. To achieve this, the study is guided by the following objectives with respective key research questions and uses both qualitative and quantitative data gathered through community participation and a household survey respectively in central and southern parts of Malawi. Different empirical methods have been employed, and empirical results are presented in chapters four to six.

Objective 1. To understand farm household perceptions, knowledge and impacts of varying and changing climate in smallholder farming.

1.1 How do smallholder farmers perceive climate variability and change, and how does it compare with the meteorological data?

The perception and understanding of climate change by non-experts have been a topic of interest for researchers and policymakers as perceptions of climate change may vary among people. Not everyone has equal access to climate change information, and again in the absence of reliable information, people may fail to perceive climate change ([Habtemariam et al., 2016](#)). Further to this, [Krosnick et al. \(2006\)](#), argued that even if the information is accessible, as individuals have different cognitive skills, some may be unable to accurately analyse available information. Perceptions among individuals differ because of differences in economic, environmental, cultural and political implications of climate change ([Broomell et al., 2015](#)). Hence, according to [Kahan et al. \(2011\)](#); [Weber \(2012\)](#), implications of climate change vary according to the socio-economic, demographic, geographical, political and other conditions of individuals.

1.2 How do climate variability and change perceived to affect smallholder common bean farmers?

There are growing concerns about how rain-fed bean production systems will be able to sustainably meet increasing demand in the context of climate change ([Challinor et al., 2014](#);

Ramirez-Cabral *et al.*, 2016). It has been estimated that changes in climate have already been reducing global agricultural production by 1–5 percent per decade over the last 30 years (Challinor *et al.*, 2014). Studies done by Ramirez-Cabral *et al.* (2016) in South America indicated that, in the absence of adaptation strategies to the changing climate, agricultural productivity is expected to reduce consequent to food insecurity and a systematic decrease in the climatic suitability for common bean cultivation is projected, with heat and drought stresses being the key drivers for such suitability reductions.

1.3 How are decisions on the use of adaptation strategies made in smallholder farming?

The study done by Belay *et al.* (2017) on smallholder farmers' adaptation to climate change and determinant of their adaptation decisions in central Rift Valley of Ethiopia found that the majority of the smallholder farmers who perceived climate change made decisions to use adaptation strategies to climate change. These decisions include using practices like crop diversification, planting date adjustment, soil and water conservation and management, increasing the intensity of input use, integrating crop with livestock, and tree planting. Further, using an econometric model, they found that education, family size, gender, age, livestock ownership, farming experience, frequency of contact with extension agents, farm size, access to market, access to climate information and income were the key factors determining farmers' choice of adaptation practice.

1.4 Do men and women perceive and respond the same to climate variability and change?

Objective 2. To understand factors affecting smallholder farmers' decision-making, and direct involvement in performing bean production activities at farm household level in the face of climate variability and change

2.1 What affects participation in decision-making in bean production activities in smallholder farming?

Mengesha (1990) found that household decision-making is neither necessarily unitary nor harmonious. Different members may decide about production approaches, contribute labour to particular tasks, or bear responsibility for the use of commodities produced. The intricacy of intra-household dynamics implies that the probability of contending goals or priorities may require negotiation among household members. Households are also fluid or flexible. Variability emanates from responses to exogenous changes (such as male emigration), from internal differentiation based on class, income, ethnicity, and culture, and from demographic

variables within the household unit (such as the pattern of family formation or the life cycle of the family). On average, decisions in major areas that transform the conditions of life in the household are generally made by the male head of the extended family (Luhmann & Maurer, 2007; Mengesha, 1990).

2.2 Do males and females have equal participation in decision-making in bean farming activities?

2.3 What influences direct involvement in undertaking bean production activities in smallholder farming?

Nakazi *et al.* (2017) found differences in terms of how men and women participate in bean production activities despite that no activity is purely conducted exclusively by men or by women. The study identified five activities in which most rural women comprehensively participate, i.e., winnowing, post-harvest handling and storage, sorting, planting and weeding. Similarly, the activities in which men mostly participate include site selection, spraying against pests and diseases, bush clearing, fertilizer application, and harvesting. Despite some variations, there is a clear-cut division of labour between the sexes in subsistence traditional agriculture and generally, female contribution to agricultural activities decreases with intensification of the particular activity (M. L. Burton & White, 1984). The amount and type of cooperation between the sexes would vary according to cropping patterns and the time allocated to activities other than farming. The extra effort required in farm work is met by more intensive use of female labour. Women's intensified work input does not improve their personal standing in the household (Mengesha, 1990). Considering the discussion above, there is a need to close the gender gap in bean production through targeting both genders with gendered interventions and address issues of traditional norms (Nakazi *et al.*, 2017).

2.4 Do males and females have equal direct involvement in performing bean farming activities?

Objective 3. To understand climate resilience in smallholder farming through the use of objective and subjective approaches.

3.1 What factors influence resilience to climate variability and change, in smallholder farming?

There are questions around the use of objective approaches to measure climate resilience as these relate to the approaches that solicit little, if any, judgement on behalf of the subject in question. Recently, a contrasting epistemological view that relies on people's self-assessments

of their own capacity to deal with the climate shocks have been proposed owing to offer some promise to complement objective approaches (Jones, 2019).

3.2 How resilient are farmers across different geographical locations in smallholder farming?

Makate *et al.* (2019) found that multiple innovations adoption has far greater benefits on productivity and income when considered individually. However, impacts of multiple adoption of the practices are not entirely uniform across different geographic regions and gender, hence, farmers' resilience varies.

1.4 Outline of the thesis

This thesis is structured under seven chapters, including this introductory chapter. Chapter 2 provides the literature review of the study. Having defined some key concepts and terminologies, it provides an overview of farmers' perceptions, knowledge, and possible impacts of climate variability and change, participation in decision-making and direct involvement in bean production activities, and objective and subjective approaches to understanding climate resilience in smallholder farming. It also provides the theoretical and empirical substantiation on farmers' resilience to climate variability and change in smallholder farming. Chapter 3 presents the methodology of the study; research approach and epistemology, study location and respondents, data collection (methods and tools), data analysis, researcher's perspective, positionality and reflexivity, and limitation of the study. Chapter 4 presents Objective 1 results and discussions; it understands perceptions, knowledge, and impacts of the changing climate in smallholder farming in Malawi. It further analyses decision-making in the use of climate change adaptation strategies in smallholder farming. Chapter 5 presents Objective 2 results and discussions; it analyses participation in decision-making and direct involvement in bean production activities in smallholder farming in Malawi. Chapter 6 presents Objective 3 results and discussions and understands resilience in smallholder farming in Malawi using objective and subjective approaches. Finally, chapter 7 presents the conclusions and policy implications of the research findings, and associated recommendations for further research.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

This chapter reviews theoretical and empirical literature relating to the resilience of smallholder farming to climate variability and change. The chapter starts by offering some definitional facets of the terms and concepts of the study, namely, smallholder farmers, perception, climate variability and change, climate resilience, gender, objective and subjective measures of resilience. A thorough understanding of these terms and concepts is important in explaining smallholder farmers' resilience to the changing climate in the study areas. The chapter also reviews literature on factors driving farmers' perceptions of climate variability and change, knowledge, response and impacts of climate change, decision-making, and direct involvement on production activities at farm level. This is followed by presentation of the theoretical and empirical substantiation of resilience to climate variability and change in smallholder farming.

2.2 Concepts and definitions

2.2.1 *Smallholder farmers*

A universally accepted international definition of “smallholder”, is still debated despite being a focal point of smallholder agriculture in the current development narrative. In essence, a general and operational definition of smallholder does not exist. In the literature, definitions of “smallholder farmers” fluctuate considerably, depending on the farm characteristics taken into account, ranging from socio-economic features, to resource endowments and agro-ecological dimensions. The term “smallholder” often extends over, and may be used interchangeably with, “small-scale agriculture”, “family farm”, “subsistence farm”, “resource-poor farm”, “low-income farm”, “low-input farm” or “low-technology farm” (Brüntrup *et al.*, 2002).

The concept of “smallholder farmer” can be advanced from diverse perspectives which are linked to the objective of the analysis. From a general viewpoint, smallholders normally operate under structural constraints such as access to sub-optimal amounts of resources, technology and markets.

In [Khalil Clara Aida \(2017 p 8\)](#), “a small farm” has been explained and systematically defined based on Report of the High-Level panel of Experts on Food Security and Nutrition [HLPE \(2013 p 23\)](#) as:

“An agricultural holding run by a family using mostly (or only) their own labour and deriving from that work a large but variable share of its income, in kind or in cash. The family relies on its agricultural activities for at least part of the food consumed – be it through self-provision, non-monetary exchanges or market exchanges. The family members also engage in activities other than farming, locally or through migration. The holding relies on family labour with limited reliance on temporary hired labour but may be engaged in labour exchanges within the neighbourhood or a wider kinship framework”.

It is clear that defining smallholders is complex as no one-size-fits-all definition exists, hence, the “right” definition will likely depend on the particular purposes of the analysis and the trade-off between completeness and feasibility ([Khalil Clara Aida, 2017](#)). It should also be consistent with the concepts of absolute poverty and severe food insecurity, which are at the basis of the sustainable development goals (SDGs) policy agenda and must be based on a criterion that does not depend upon outcomes that have to be measured ([Offutt, 2016](#)). In view of this, smallholders are defined differently based on a single criterion - the endowment of factors of production such as land, labour, technology, and the type of management of the holding. Notably, based on combinations of the criteria reviewed so far, this includes the degree of involvement of the family, the connection between the farm and the market (market-orientation), and economic size of the holding, measured, for instance, through the value of production. While being comprehensive in nature, these approaches are seldomly operationalized in statistical terms, let alone used to produce internationally comparable indicators ([Khalil Clara Aida, 2017](#)). [Barnett et al \(1997\)](#) defined smallholders as “farmers associated with activities which together form a livelihood strategy where the main output is consumed directly, where there are few if any purchased inputs and where only a minor proportion of output is marketed.” [Narayanan & Gulati \(2002\)](#) defined smallholders as farmers (crop or livestock) practicing a mix of commercial and subsistence production..., where family provides the majority of labour and the farm provides the principal source of income”. The [World Bank \(2003\)](#) defined smallholders as those with a low asset base and operating in less than 2 hectares of cropland. [Dixon, Tanyeri-Abur, & Wattenbach \(2004\)](#) defined smallholders

as farmers with limited resource endowments, relative to other farmers in the sector. [Murphy \(2012\)](#) defined smallholders with a focus on the nature of the farm's production rather than the size of the landholding. He argued that yet while the size of a landholding as a proxy for small-scale production is useful, it is not an all-encompassing definition as it leaves out important groups of small-scale farmers and is relative to national and contexts, and 'smallholders' in transitional or developed countries may have farms (and incomes) many times larger than those in developing countries.

The term smallholder farmer is used in both technical and nontechnical contexts. In technical sense is sometimes used to denote the activity of self-provisioning with agricultural produce or a relative move toward such activity ([Abele & Frohberg, 2003](#)). It is also frequently used in a nontechnical sense to describe the rural poor of developing countries. Taking into consideration that market relations have entered deeply into agriculture in virtually all parts of the world, such usage diverts attention and that many of these farmers' most important problems stem from the terms of their inclusion in the market([Ellis, 2005](#)). Smallholder farmers are heterogeneous in terms of their access to productive assets, connectivity to different markets and the functionality of those markets in improving the productivity and income-generating ability. [Figure 2.1.](#) presents useful overview of the details of heterogeneity of smallholder farmers, which provide possible entry points for diagnostic analyses of specific cases and for possible policy interventions ([FAO, 2013](#)). The figure further illustrates the basic characteristics of smallholder farmers that directly describe smallholder farmers in Malawi e.g. resource base, decision- making, technology, risk factors, and food security. Whether or not single criterion or multiple criteria are used in defining smallholders, the distinctions, similarities and constraints highlighted above are typical characteristics of smallholder farmers in Malawi ([Tchale, 2009](#)), except for some aspects of technology (i.e. high land productivity, technically efficient, and resilient agriculture). Connectivity to markets and market functionality are beyond the scope of the unit of analysis in this study. The next sub-section describes the concept of perception.

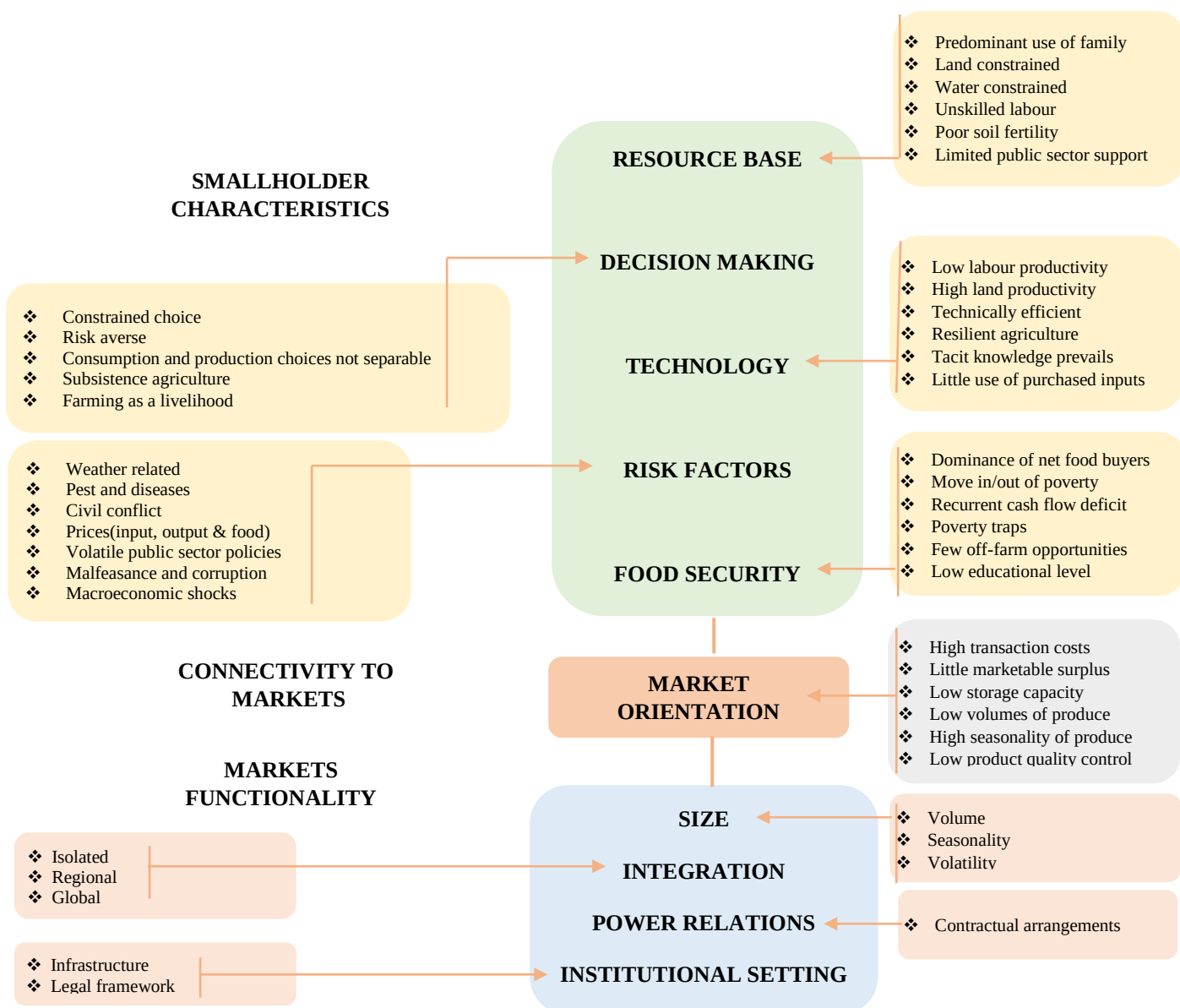


Figure 2. 1. Smallholder characteristics affecting market participation

Source: FAO, 2013.

2.2.2 Perceptions

Perception is a process of receiving information and stimuli from our surroundings and converting them into psychological responsiveness. This process is normally defined in three stages which include selection, organization, and interpretation. Selection involves conversion of environmental stimuli into meaningful experience, organization involves arranging the stimuli in some way by finding certain patterns, and interpretation involves attaching meaning to the selected stimuli (Qiong, 2017). According to Otara (2011), perception not only creates our experience of the world around us; it allows us to act within our environment. Despite countless ways of how perception is described, most psychologists describe it in three folds: i) sensory stimulation, organization of the stimulus in one's brain which strives to organize things in such a way that they make sense to us, ii) interpreting and iii) expressing the thoughts that have been elicited. Additionally, these stages of perceptual process are influenced by a number of factors which include, but are not limited to, habit, motivation, learning, specialization and social background.

According to Walker & Avant (2005), a theorist introduces the reader to the critical defining attributes by using theoretical definitions, which are usually abstract and may not be measurable. In order to measure a concept, an operational definition is employed.

An operational definition of perception includes: an individual's or group's unique way of viewing a phenomenon involving the processing of stimuli incorporating memories and experiences in the process of understanding. It should be pointed out that perception is never objective because the same thing can be perceived differently by different individuals or groups.

Understanding trends in complex and variable climatic phenomena can be problematic for farmers and reservations have been articulated about their ability to accurately distinguish climatic trends from casual observations and consistently unify varied direct and indirect sensory impressions (Kempton *et al.*, 1997). Moyo *et al.* (2012) question the comprehensiveness of perceptions, arguing that perceptions characterize simplified versions of a complex reality and are subjective in nature.

2.2.3 Climate variability and change and current status of climate variability and change perceptions research

2.2.3.1 Climate variability and change

Among climatologists, there is no unanimity on the definition of the term climate, and let alone climate change, trend or fluctuations. Again, how to define climate and climate change is non-trivial and contentious, which is conceptually interesting. However, choosing good definitions is also important to validate statements about our climate system (Werndl, 2016). Houghton (2002), defined climate change with reference to specified geographical regions as the average state of the atmosphere for a given time scale (hour, day, month, season, year, decades and so forth). This is attributed indirectly or directly to human activities that alter the composition of the global atmosphere and in addition to natural climate variability, observed over comparable time periods. Beyond individual weather events such as prolonged droughts and severe floods (climate variability), the increased variations in the mean state of climate on temporal and spatial scales, which is evident over a time period ranging from months to thousands or millions of years, indicates that the climate is changing (Hegerl et al, 2007; Solomon & Qin, 2013). According to Werndl (2016), using five desiderata (empirically applicable, correctly classify different climates for time periods, not dependent on our knowledge, applicable to the past, present and future, and mathematically well-defined) on a definition of climate, defined it in five different ways as follows;

- ❖ Climate as the finite distribution of the climate variables over time for constant external conditions (Definition 1).
- ❖ Climate as the finite distribution of the climate variables over time when the external conditions vary as in reality (Definition 2).
- ❖ Climate as the finite distribution of the climate variables over time relative to a regime of varying external conditions (Definition 3).
- ❖ Climate as the ensemble distribution of the climate variables over time for constant external conditions (Definition 4) and,
- ❖ Climate as the ensemble distribution of the climate variables over time when the external conditions vary as in reality (Definition 5).

Definition 3 is considered a novel contribution and was proposed as a response to problems with the other four definitions which are among the most commonly endorsed definitions of climate.

2.2.3.2 The current status of climate change perceptions research

Farmer perceptions of climate variability and change research, within a development context, has advanced in the last few years with multitudinous articles being published on the subject from across the developing world. Much of the research, reports that farmers undeniably note an increased trend in temperature, delayed onset and decreased rainfall amounts, drying up of water sources, increased incidence of extreme events and declining agricultural productivity. Based on emerging themes from literature and the extent to which perceptions are critically evaluated, farmers perceptions have been categorized into four major themes of research or research typologies.

2.2.3.2.1 *Descriptive perceptions research*

This type of perception is characterized by studies that take farmer perceptions of climate variability and change at face value, without comparing them to the historical meteorological data and with no critical analysis of the factors that lead to the construction of these perceptions. A large majority of descriptive perceptions research tends to emerge from within climate change adaptation research, which goes some way in explaining the post-perception focus. Thus, decision-making and adaptation strategies tend to dominate, whilst critical interrogation of farmer perceptions tends to be overlooked. Although this research provides interesting insights into what climatic changes farmers perceive, it provides little insight into how and why farmers have these specific beliefs about climatic change, risk and uncertainty.

[Ogalleh et al. \(2012\)](#) looked at farmer perceptions of climate variability and change in Laikipia District in Kenya in the context of investigating adaptation strategies. The researchers found that farmers perceive that rainfall was more regular and predictable in the 1960s, 1970s and 1980s, when farmers first settled in the area. Eighty eight percent of farmers expressed that the climate was ‘good’ in the past and 89 percent said that the current climate was ‘bad’. Farmers in Laikipia also perceived a decline in rainfall and increased temperature and wind speeds.

[Ogalleh et al. \(2012: 3307\)](#) highlight the “ability of farmers to value their climate as either ‘good’, ‘constant’, ‘bad’ or ‘very bad’... an indicator of their in-depth local knowledge and perceptions”. Moreover, in addition to climatic perceptions of rainfall and temperature, the researchers utilized farmer perceptions of indirect indicators such as incidence of crop and animal disease, frequency of drying rivers and frequency of hunger, inferring that the causation of these observations is directly linked to climate variability and change, rather than multiple

factors or stressors. The study employs some precipitation data and the Palmer Drought Severity Index (PDSI), but no other climatic data is used for comparison of farmer perceptions of specific climatic changes and the climate record.

[Legesse et al. \(2012\)](#) explored farmer perceptions of climate variability and change in West Hararghe, Ethiopia. Their findings (descriptive statistics) show that the majority of farmers perceive an increase in temperature, greater unreliability of rainfall, declines in rainfall amounts and increased drought. Moreover, they note that the majority of farmers faced crop failure in the previous decade (63.3 percent of men and 71.4 percent of women) and all respondents had experienced “major hazards related to climate variability and change” ([Legesse et al., 2012: 258](#)). Nevertheless, they assume that crop failure is directly associated with climate variability and change; no description is provided of the hazards experienced. They found that perceptions of climate variability and change amongst men and women do not differ statistically, concluding, “there are no multiple perceptions or varying insights amongst the sample population” ([Legesse et al., 2012: 264](#)). It is important to note the researchers did not explore the social mechanisms that would lead to gendered perceptions being so closely aligned across their study sites, nor compare farmer perceptions with the historical climate data.

2.2.3.2.2 Comparative perceptions research

Comparative perceptions research involves direct comparison of farmer perceptions of climate variability and change with the historical meteorological data. This type of perceptions research seeks to test the precision and dependability of farmer perceptions, without necessarily exploring the reasons for possible orientation or disorientation of perceptions with the historical climate data and the factors that lead to the construction of specific perceptions.

[Vedwan & Rhoades \(2001\)](#) examined the perceptions of climate variability and change of apple farmers in the western Himalayas of India, using snow and rainfall data to measure the accuracy of farmer perceptions. They found that farmers described climate change as a temporal displacement of the normal weather calendar and that perception of climate variability and change is structured by the crop-climate interaction. [Hageback et al. \(2005\)](#) investigated the perceptions of climate change of smallholder farmers in the Danagou Watershed in China. They compared precipitation and temperature trends and the responses that were given by farmers to the question: “Do you feel there are any changes in climate now compared to twenty

years ago?” Their research showed that farmer perceptions of climate change aligned with the historical climate data.

[Kashaigili et al. \(2014\)](#) studied farmer perceptions of climate variability and change in coastal Tanzania. They highlighted that farmers perceived a decline in rainfall amount, increased temperature, increased incidence of crop and livestock diseases and the disappearance of pre-existing wetlands. They compared these perceptions with meteorological data and concluded that community perceptions were consistent with climate variability and change. [Egbe et al. \(2014\)](#) noted that 86 percent of farmers in the Cross-River State in Nigeria believed that the climate was changing as a result of changes in the onset of the rainy season, warmer temperature, reduced vegetation, soil fertility, as well as increased food insecurity. However, when comparing farmer perceptions to the observed climate record, they utilized only three average data points over a twenty-year period and failed to emphasize the fact that perceptions did not match the observed meteorological data in terms of rainfall. Both studies argue that factors such as poor crop yields, increased crop and livestock disease, reduced pastures and poverty directly result from climate variability and change, rather than recognizing the existence of multiple stressors that could result in the emergence of these circumstances. Because both studies obtained perceptions information that aligned with the climate record, they naturally assumed that perceptions are a true reflection of reality and are shaped merely by observation. As a result, no critical examination of the perceptions themselves or the factors that lead to their construction are addressed. It is also important to note that both studies employed climate data from meteorological stations that were a significant distance from their study sites, which may lead to issues with spatial variability. In particular, [Kashaigili et al. \(2014\)](#) utilized data from Dar es Salaam, a coastal city in East Africa, whilst their study sites were located inland.

2.2.3.2.3 Comparative Contextual Perceptions

Comparative contextual perceptions research, as a theme or research typology, is characterized by an attempt to situate farmer perceptions within social, cultural, economic, political and environmental contexts. This research, although not exhaustive, begins to go beyond the ‘observation = perceptions’ paradigm and makes some attempt to explain farmer perceptions of climate variability and change.

Gbetibouo (2009) highlighted the fact that climate change is expected to have serious economic, environmental and social impacts on South Africa. The study focused on smallholder perceptions and adaptation in the Limpopo Basin and found that smallholder farmers perceive an increase in temperature and that the climate record supports these perceptions. However, it was found that farmers perceived a decline in rainfall over the past 20 years, but in terms of rainfall amounts, no statistically significant trend could be observed in the climate data. Beyond simply describing and comparing farmer perceptions of climate variability and change, Gbetibouo (2009) investigated which farmers perceive changes, based on a number of socio-economic and environmental variables. The study found that knowledge changes the probability of farmers noting a long-term trend in rainfall - more experienced farmers are more likely to perceive a change in temperature, and farmers with access to irrigation are less likely to perceive any changes in rainfall and temperature. Further to this, the study found that a farmer's access to extension services tends to increase the probability that they will perceive a change in temperature and farmers with high soil fertility were significantly less likely to perceive climate variability and change. Interestingly, the study also found that farmers living in the wealthy province of Gauteng, where agriculture makes up a small proportion of the economy and livelihoods are generally more diversified, were less likely to perceive changes in rainfall and temperature trends. Meze-hausken (2004) in a study looking at perceptions of climate variability and change in Northern Ethiopia, highlighted that a divergence in perceptions and the climate record may arise as a result of people's actual rainfall needs and are, therefore, judged against them. Moreover, she noted that the complex and diverse rainfall needs of different agricultural livelihoods might lead to entirely different perceptions. Therefore, "any analysis of subjective observations about weather and climate requires a deeper investigation of the socio-economic, cultural and environmental conditions experienced by the affected people" (Meze-hausken, 2004: 30). Tunde (2011) looked at gendered perceptions, based on the different crops that men and women grow in Ondo State, Nigeria. Interestingly, it was found that men and women do have different perceptions of climate variability and change, but only a general explanation for this difference was provided by the researcher: "The investigation shows that changes in climatic variables, poverty and environmental pressure led to vulnerability of which greater proportion of women farmers are more affected than men as a result of the multiple significant roles in food security" (Tunde, 2011: 31).

2.2.3.2.4 Comparative critical perceptions research

As an emerging theme or typology of research in the literature, comparative critical perceptions research is characterized by a critical examination of the factors that lead to the alignment or misalignment of farmer perceptions of climate variability and change which situates this within a social, cultural, economic and environmental context. It recognizes multiple stressors of agricultural production and interrogates the ‘observation = perception’ paradigm in order to provide a more holistic view of farmer perceptions. Importantly, this theme interrogates the evolution of climate change as an idea, from its origins in the natural sciences to one that has taken on social, economic, cultural and political meaning (Hulme *et al.*, 2009). In addition, this theme of research attempts to probe the differences between natural climate variability and climate change while examining how these come together to construct farmer perceptions.

Osbaahr *et al.* (2011) looked at farmer perceptions of climate variability in Mbarara District in southwest Uganda. The study location was selected close to the meteorological station to minimize the impact of spatial variability. They explored farmer perceptions of temperature and a number of rainfall parameters, such as rainfall amount, the average number of rain days and the length of the longest dry spell. Other climatic events were also investigated including the start and end of the rainy season and extreme events, such as drought. The study found that although farmers perceive a change in temperature, rainfall seasonality, distribution, intensity, amount and an increase in incidence of extreme events, “only temperature had a clear signal in the climate record” (Osbaahr *et al.*, 2011: 314). They emphasized the fact that farmers normally tend to remember extreme weather events more readily than they are able to describe slower climate trends, arguing that this is a “natural reflection of human perception and memory” (Osbaahr *et al.*, 2011: 312). Importantly, they noted that most often farmers reported problems in the seasons directly following extreme events and suggest that although in most cases weather events were the causal factor, they are interrelated with other factors. “More explicitly, it may be production that farmers recall, rather than the climate” (Osbaahr *et al.*, 2011: 312). Therefore, it can be reasonably assumed that poor production may not be necessarily linked to climate, but a host of other factors, such as economic circumstances, but because production falls below a threshold, farmers may naturally consider it a drought year. Meze-hausken (2004) noted a similar phenomenon in Ethiopia. Osbaahr *et al.* (2011: 312) highlight that it is the “impact on livelihoods that is most important, rather than the cause, in defining drought from the viewpoint of local people”. These farmers’ perceptions of drought come close to the concept of ‘agricultural drought’, but they do not include a multitude of external factors that

can lead to the poor economic condition of households. This study emphasizes the importance of household vulnerability in the construction of perceptions. As a result, the researchers argue that perceptions are, in fact, socially constructed. [Osbaahr et al. \(2011\)](#) also attempt to unpick the natural variability in climate and climate change. They note that in Uganda there is a focus on the impacts of climate change by the government, the aid and non-governmental organization (NGO) sector, as well as the local people. As such, there may be a tendency to portray natural variability or abnormal climatic events as characteristics of change, due to the fact that it is often easier for farmers to associate the causality of changes in their production to climate, rather than the complex social, political, economic and environmental factors, that all contribute to and impact their production ([Osbaahr et al., 2011](#)). Moreover, part of farmers' perceptions can be attributed to the amount of rainfall that they require to achieve their desired production and, therefore, any rainfall received is judged against this ([Osbaahr et al., 2011](#)). The researchers highlight a need for more in-depth research into subjective perceptions and the socio-economic, cultural and environmental factors that influence farmer perceptions.

[Moyo et al. \(2012\)](#) investigated farmer perceptions of climate variability and change and their alignment with the historical climate data in two districts of semi-arid Zimbabwe (Agro-ecological Zones IV and V). The study showed that farmers perceived climatic and weather patterns to have shifted over the last two decades, in particular, increased variability and uncertainty in onset and cessation and distribution of rainfall, reduced rainfall amounts and increased temperature, which all contributed to decreased agricultural productivity and increased livestock morbidity and mortality. They showed that no clear signal was found in the historical climate data to support farmers' perceptions of rainfall changes; however, farmer perceptions of rising temperature were corroborated by the climate data. As a result of this misalignment of farmer perceptions with the climate record, [Moyo et al. \(2012\)](#) posit the influence of other non-climatic factors. Moreover, they note that farmers do not necessarily consider 'poor' seasons in meteorological terms, due to the fact that seasons with average or above average rainfall can still be classed as poor seasons. Farmer memory is flagged as being problematic because farmers have problems distinguishing between climate (the statistical expectation) and weather (what they actually get). Therefore, because farmers largely rely on experience and observation to inform their perceptions, this can lead to increased unreliability of perceptions, which can result in inappropriate agricultural and livelihood decision-making. The study argues that expectation of climate change also plays a significant role in the construction of farmer perceptions of climate variability and change. Therefore, if farmers are

over-sensitized to the idea of climate change, they may be more likely to perceive changes in their climate. Much like the study by [Osbahr et al. \(2011\)](#), the researchers found that farmers remember the extremes in climate as well as the more recent years with reduced crop productivity. This is an important concept, as it helps to illustrate the manner in which perceptions are dynamic, changing over time as experiences of good and bad seasons occur. The study found that farmers tend to overestimate the likelihood of ‘poor’ seasons and as a result of this, tended to under-invest in resources, such as inputs, labour and in the adoption of new innovations.

[Slegers \(2008\)](#) looked at farmers’ perceptions of drought in semi-arid East Africa, specifically Tanzania and Ethiopia. The study emphasizes the discord between farmer and expert opinion into what is the major factor limiting agriculture in the region, with scientists identifying human-induced land degradation as the major limiting factor, whilst farmers attributed declining agricultural yields to drought ([Slegers & Stroosnijder, 2008](#); [Slegers, 2008](#); [Stroosnijder, 2009](#)). The study showed that farmers’ perceived increased frequency and severity of drought years and that the weather pattern had become less predictable. The study highlights that farmers perceive differences in drought vulnerability based on the characteristics of the land, particularly soil type, fertility and erosion. Moreover, characteristics of the farmer’s ability and attitude contributed to their perceptions of drought vulnerability. Weaker farmers, in particular the old and sick, were identified as being more susceptible to drought due to their reduced capacity to cultivate as much land. Wealth played a role too, with older and richer farmers more able to afford to buy short-season varieties and to plough mechanically. Farmers tended to remember the most extreme weather events and the most recent years with reduced productivity, with older farmers remembering extreme seasons further back in the past. Memory of specific droughts, however, was characterized by the personal impacts on farmers’ livelihoods, rather than specific memory of reduced rainfall. This raises the important question of accuracy – can farmers misinterpret tough times as drought even when there is adequate rainfall, because of issues with memory? Many of the respondents in the study believed that deforestation was a cause of reduced rainfall, as well as untimely planting. Farmers also attributed increased drought incidence to the dissatisfaction of God or their ancestors. [Slegers \(2008\)](#) notes that experiential knowledge dominates the way in which farmers perceive drought, with the most commonly used signs being the current weather conditions. Ultimately, it is the idea that farmers’ “perceptions are area-specific constructs

influenced by local biophysical, social, cultural, economic and political conditions” that is the most important aspect of this study.

It must be noted that the majority of research has simply described farmer perceptions and falls under the themes of descriptive and comparative research, with little critical interrogation of both the perceptions and the factors that lead to their construction. The gaps identified and the questions raised in the existing literature on perceptions highlight the need for research that does not just take perceptions at face value, because they do or do not align with the climate data, but rather critically explores why and how the perceptions are constructed in order to gain a more nuanced understanding. Saying this, research by (Moyo *et al.*, 2012; Osbahr *et al.*, 2011; Slegers, 2008) has, to some extent, taken a more critical look at farmer perceptions of climate variability and change and has made attempts to illustrate the complexity of the construction of these perceptions. However, unlike many, this research uses a combination of descriptive, comparative, contextual and critical research as a pathway to understanding smallholder farmers’ climate resilience.

2.2.4 Resilience to climate change

There myriad of definitions of resilience may not be exhaustive. In Alinovi, Mane *et al.* (2010), the concept of resilience, was originally proposed by Holling (1973) in the ecological literature and was successively extended to investigate the relative persistence of complex dynamic systems such as socio-economic systems (Levin *et al.*, 1998). The concept of resilience has two main variants. One, called “engineering” resilience... the ability of the system to return to the steady state after a perturbation. It focuses on efficiency, constancy, and predictability, and it is the concept used by engineers in their attempts to develop optimal designs (“fail-safe” designs). The other definition, we can refer to as “ecological” resilience, is the magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behaviour. It focuses on conditions away from any stable steady-state, where instabilities can flip the system into another regime of behaviour (i.e., to another stability domain). For purposes of this study, more recent conceptualization of resilience would be adopted with regards to human systems which give greater recognition to the potential needs of a system to adapt to and change its core structures and functions with some cases requiring even transformation (Aldunce *et al.*, 2015).

Southwick et al. (2014) propose a definition of resilience which highlights the determinants or drivers of resilience, and the most effective ways to enhance resilience. Other proposed definitions of resilience include a stable trajectory of healthy functioning after a highly adverse event; a conscious effort to move forward in an insightful and integrated positive manner as a result of lessons learned from an adverse experience; the capacity of a dynamic system to adapt successfully to disturbances that threaten the viability, function, and development of that system; and a process to harness resources in order to sustain well-being.

Wald et al. (2006), note that a number of these definitions bring into question the notion that resilience is characterized by the absence of functional impairment or psychopathology following highly adverse events. Upon recognising the complexity of resilience construct, current research has emphasized the importance of continued research directed towards establishing empirically driven operational definitions of resilience that may have specific meaning for a particular individual, family, organization, society or culture. The premise behind defining resilience is not to agree on one definition of resilience, but rather to carefully define various types of resilience depending on context. On the other hand, in order to establish a single broader, but nevertheless useful, definition of resilience, it will be essential to collaborate with experts who study engineering, ecological, biological, individual, family, organizational and cultural resilience.

Herrman et al. (2011), suggest that recent research has discussed the need to approach understanding of resilience and its determinants from multiple levels of analysis, including genetic, epigenetic, developmental, demographic, cultural, economic and social. This approach promises positive outcomes because specific determinants generally serve as relatively weak predictors of resilience by themselves and explain a relatively small piece of the puzzle. Again, determinants of resilience may also differ depending on context and specific challenges. While it is useful for researchers to identify general principles related to resilience, it is also important to recognize that successful determinants may vary from one person to the next based on multiple factors such as personality, specific challenges, resources available, and environmental context. In addition, there is evidence suggesting that resilience is associated with the ability to employ a variety of coping strategies in a flexible manner depending on the specific challenge, and then to use corrective feedback to adjust those strategies. Further, the determinants of resilience may vary depending on the age and maturity of the individual.

Southwick *et al.* (2014) posit that in order to develop effective interventions to enhance resilience, it is critical to understand that humans are embedded in families, families in organizations and communities, and communities in societies and cultures. Interventions targeted at any one of these levels will impact functioning at other levels. Sometimes the most effective strategy to enhance resilience at a specific level may involve intervening on a different level. For example, to enhance resilience in a young child it may be more effective to provide schools and parents with needed resources (e.g., healthy meals; education on how to raise children) than to intervene at the level of the individual child. Similarly, communities may enhance individual resilience by providing job training and placement for those who are unemployed. In other words, resilience in the individual is highly dependent on multiple layers of society. It is also important to understand that determinants of resilience in one community may differ from those in another community, and that some skills needed to successfully deal with one stressor/trauma may differ from those needed to cope with a separate traumatic situation. To develop effective resilience-enhancing interventions that are informed by an understanding of these complexities, experts from a broad range of disciplines will need to work together and listen carefully to one another as well as to those who are actually facing trauma. Interventions to enhance resilience can be administered before, during or after stressful/traumatic situations. Some interventions may be more effective at one time point than another. Ideally, interventions/training will occur prior to stressful events so that the individual is better prepared to deal with adversity. Humans are endowed with great potential to weather adversity and to change or adapt when necessary, but they need basic social and material resources to do so. One of the most important ways to foster resilience is to promote healthy family and community environments that allow the individual's natural protective systems to develop and operate effectively

2.2.5 Gender and climate change

2.2.5.1 Gender

There have been misconceptions on how gender and sex are more often than not being used interchangeably. Sociologists describe sex as the relatively unchanging biology of being male or female, while gender refers to the roles and expectations attributed to men and women in a given society, roles which change over time, place, and life stage. Genetic makeup and hormone profile are both examples of sex, that is, of biological characteristics, which tend to be constant across societies. Gender is a social, rather than a biological construct, and varies with the roles, norms and values of a given society or era. Fundamentally, being able to bear a child is a function of biology, while expectations about the imperative to bear children, the nature of parenting, or the status associated with being a mother are more closely linked to gender roles and expectations (Phillips, 2005).

Rubin *et al.* (2009), defines sex as biological characteristics that distinguish males and females which do not change from one culture to another and can be recognized as independent and distinct from one another. While gender is defined as the social category usually associated with being a man or a woman. It encompasses economic, social, political, and cultural attributes and opportunities as well as roles and responsibilities. Gender is defined differently around the world and those definitions change over time.

Njuki *et al.* (2011) defined gender as ‘the socially constructed roles and status of women and men, girls and boys. It is a set of culturally specific characteristics defining the social behaviour of women and men, and the relationship between them. Gender roles, status and relations vary according to place (countries, regions, and villages), groups (class, ethnic, religious, and caste), generations and stages of the lifecycle of individuals. Gender is, thus, not about women but about the relationship between women and men.’

These definitions emphasize the characteristics of sex and gender as binary differentiation of being male and female, and roles and responsibilities associated with males and females respectively. The subsequent section reviews perceptions, knowledge, and impacts of climate variability and change at household level.

2.2.5.2 Gender and climate change

Climate change is increasingly being recognised as a global crisis, but responses to it have so far been overly focused on scientific and economic solutions, rather than on the significant human and gender dimensions. As weather patterns become increasingly unpredictable and extreme events such as floods, heat waves or natural disasters become more common, the poorest women and men in the global South – who have contributed the least to the problem – find their livelihoods most threatened yet have the weakest voice and least influence on climate policy” (Aboud, 2011). But what have disparate power between women and men and international inequality got to do with an environmental crisis as mammoth as the negative effects of climate change that are predicted to have extensive consequences for both women and men? (Denton, 2002b). It has been assumed that climate change and other incidents associated with climate change are “oblivious to boundaries” and should, therefore, “affect the lives of women and men equally”. The welfare of our planet is of global concern and as such requires a collective input in its management and sustainability. Nevertheless, “climate negotiations could be seen as a parody of an unequal world economy, in which men, and bigger nations, get to define the basis on which they participate and contribute to the reduction of growing environmental problems, while women, and smaller and poorer countries, look in from the outside, with virtually no power to change or influence the scope of the discussions” (Denton, 2002b). More than a decade since the climate debate began it continues to be laden with problems, moving from an initial commitment to greenhouse gas (GHG) mitigation to an attempt to get noncompliant nations, such as the USA, to conform and ratify the Kyoto Protocol. Further to this, it is evident that the climate change debate has been dominated by and has consistently reflected the interests and priorities of the developed world. Seldom have the issues facing people living in poverty been adequately addressed, especially in terms of adaptation (Denton, 2002b). Moreover, women have been demonstrably absent from any decision-making process when it comes to the issue of climate change. Consistently, the climate debate has not addressed the marginalization of women or the need to integrate them into environmental and development policies. With women responsible for upwards of 70 percent of agricultural labour and food security in the developing world (CIDA, 2002), it is essential that the current climate change debate ensures that key stakeholders and decision makers comprehend the types of climate-related vulnerability that women and men experience, their perceptions of climate variability and change as well as their gendered implications.

2.3 Smallholder farmers' perceptions, knowledge and possible impacts of climate variability and change at household level.

2.3.1 Factors driving smallholder farmers' perception of climate variability and change.

Smallholder farm households' perception of climate variability and change is a way in which smallholder farmers think and behave in relation to climate variability and change (Wehbe *et al.*, 2006). Farmers make decisions based on what they think is likely to occur, and sometimes based on what they fear, or hope is possible which explains differences in behaviour among farmers (Legesse & Drake, 2005). In the scientific community, it is defined as the complex process by which people select and organize sensory stimulation into a meaningful and rational picture of the world (Otara, 2011).

Understanding smallholder farmers' perceptions of climate variability and change is crucial, particularly in the Sub-Saharan Africa where farmers heavily depend on rain-fed agriculture. Perception strongly affects how farmers deal with climate-induced risks and opportunities, and the precise nature of their behavioural responses to this perception will shape adaptation options (Adger *et al.*, 2009). In addition, perception is important because it influences the motivation to take action as well as the policy-formulation context for actions against climate (Grothmann & Patt, 2005; Leiserowitz, 2006). The perception and understanding of climate change by non-experts have been topics of interest for researchers and policymakers as perceptions of climate change may vary among people. Not everyone has equal access to climate change information, and, again in the absence of reliable information, people may fail to perceive climate change (Habtemariam *et al.*, 2016). Further to this, Krosnick *et al.* (2006), argued that even if the information is accessible, as individuals have different cognitive skills, some may be unable to accurately analyse available information. Perceptions among individuals differ because of differences in economic, environmental, cultural and political implications of climate change (Broomell *et al.*, 2015). Hence, according to Kahan *et al.* (2011) and Weber (2012), implications of climate change vary according to the socio-economic, demographic, geographical, political and other conditions of individuals.

In developing countries, the role of women in agriculture and food production has long been established, and thus, the role of gender in perception cannot be underestimated (Orr *et al.*, 2016). Arguments on the role of gender come from various perspectives, i.e., there is the perspective that men are more exposed to the scientific dimensions of society and women are more concerned about environmental issues that threaten their families and communities. In many patriarchal societies, agriculture is left in the hands of women (female farmers) as men

have migrated in search of job opportunities. There is also an argument that, due to increased exposure, female farmers tend to perceive better climate variables such as rainfall. This is due to their farming experience, particularly in regions where agriculture relies exclusively on rainfall (Mamba, 2016). In development discourse, women and younger people tend to have more positive perceptions of development than men and older people respectively (Essendi & Madise, 2014) which differ with an argument of perception of climate variability and change where older people perceive correctly the climate variability and change (Mamba, 2016). He argued that this is particularly because older farmers possess indigenous knowledge on how to perceive climate variables, particularly the amount of rainfall at the beginning of each farming season which is not possessed by younger farmers.

2.3.2 Smallholder farmers' knowledge of climate variability and change

Farmers' awareness of climate variability and change is an influential factor in determining the implementation of effective measures for climate change adaptation (Juana *et al.*, 2013). Again, effective adaptation to climate change impacts is highly dependent on the extent of community awareness, understanding and knowledge as a result of availability and accessibility of information on climate change (Ado *et al.*, 2019; Ajayi, 2014).

There is mixed evidence in literature regarding farmers' awareness and perception of climate change. Munthali *et al.* (2016), carried out a study in Rumphi district, northern Malawi and found that despite relative increase in the awareness about climate change among smallholder farmers, the understanding and meaning they give to the changing climate is still not in line with the scientific concept of climate change. Most farmers only relate climate change to the events that often occur in their production systems, i.e., rainfall patterns as they depend on rain-fed systems for their production. Similarly, Ozor *et al.* (2015) in a study conducted in Imo state, Nigeria, established farmers' knowledge about climate change is more local based than its scientific concept. Based on these findings, it is clear that there is limited understanding of climate change among smallholder farmers which, according to the authors, is largely attributed to insufficient access to information about climate change.

Different factors such as socio-economic, institutional, and geographical when interacting with humans (farmers) help accumulate environmental knowledge when added to past erratic climate changes. Among the factors affecting awareness of climate change are, but not limited to, the following: education, experience, family size, land holding size, productive asset ownership, and institutional access (government & private). Mustafa *et al.* (2019) found

positive relationships between education levels and awareness of climate change, which concurs with the studies by [Acquah \(2011\)](#); [Ajuang et al. \(2016\)](#); [Deressa et al. \(2008\)](#). [Mandleni & Anim \(2011\)](#), however, observed a negative relationship, noting that it is the adverse impact of climate change that keeps the person aware rather than education.

2.3.3 Impacts of climate variability and change on smallholders' livelihoods

Climate change is disputably one of the most important challenges facing African countries, principally due to their geographic orientation, low income, greater reliance on climate-sensitive sectors, such as agriculture which mostly depends on rainfall, and weak capacity to adapt to the changing climate ([Belloumi, 2014](#)). SSA is identified as the most vulnerable region to the impacts of climate change; attributed to the widespread poverty, inequitable land distribution and the declining size of farmland ([Bryan et al., 2013](#)). Temperature increases, changes in rainfall intensity and distribution, as well as increased incidences of extreme weather events (e.g., droughts and floods), prevalence and increases incidences of pests, weeds, and diseases are projected to continue to affect SSA ([Connolly-Boutin & Smit, 2016](#)). In Malawi climate change is a threat to economic growth, long-term prosperity, as well as the livelihoods of an already vulnerable population. Ninety percent of the population are dependent on rain-fed agriculture, 60 percent of whom are food insecure on a year-round-basis ([Chikwezga, 2016](#)). Climate sensitive rain-fed agriculture is a major contributor to the national gross domestic and foreign exchange earnings and supports the livelihoods of over 80 percent of Malawians who are involved in primary and secondary agricultural activities ([FAO, 2017](#)). Climate extremes and weather events severely erode the resilience and adaptive capacity of individuals and communities via declining yields and food security. Flood conditions especially in the southern part of Malawi can result in food insecurity with significant impacts on the livelihoods of poor people in rural areas as it contributes to significant losses of agricultural production ([Pauw et al., 2010](#)). In addition to floods, in the last few decades Malawi has experienced droughts during the 1978/79, 1981/82, 1991/92 and 1993/94 crop growing seasons ([Trocaire Organisation, 2006](#)). Therefore, Malawi is highly vulnerable to climate change under even modest temperature increases. Over the coming decades increased climate variability and extreme events, compounded by lack of human and technological capacity to mitigate and adapt to climate change will increase the vulnerability of chronically and transiently poor households, heavily dependent on rain-fed agriculture ([Lewis, 2004](#); [Trocaire Organisation, 2006](#)).

As the full effects of these changes are yet to be felt, there is evidence in the literature that these changes are already having an impact on agricultural production. For instance, combined infestations of pests and diseases in plants have been reported to result in losses of over 50 percent of the yield of major crops. Plant diseases are estimated to cause up to a 20 percent reduction in the yield of principal food and cash crops worldwide (Gautam *et al.*, 2013), while weeds have been found to contribute the greatest potential yield losses of up to 34 percent, more than those caused by pests and diseases (Oerke, 2006). According to Thornton *et al.* (2014), changes in climate and the frequency of extreme events may have a substantial impact on the prevalence and distribution of pests, weeds and crop diseases. Additionally, increases in minimum temperature have negative impacts on rice yields by up to 10 percent for each increase in temperature by 1°C in the dry season. Furthermore, increases in maximum temperature lead to reduced yields of maize by 1.7 percent for each day above 30°C under drought conditions.

Kotir (2010), reviewed current and future trends and impacts of climate variability and change on agriculture and food security and found that the cultivable land, growing seasons and yield level, particularly along the margins of semi-arid and arid areas, are expected to decrease and are projected to negatively affect agricultural production in SSA.

2.3.4 Smallholder farmers' response to climate variability and change

Smallholder farmers respond differently to climate variability and change, some respond through employing coping strategies, others through adaptation strategies. Taylor (1998) defined coping strategies as specific efforts, both behavioural and psychological, that people employ to master, tolerate, reduce, or minimize stressful events. Coping strategies are grouped into two, namely, problem-solving strategies and emotion-focused strategies, with the former as efforts to do something active to alleviate stressful circumstances, and the latter as efforts to regulate the emotional consequences of stressful or potentially stressful events. Literature indicates that, in most cases, people use both types of strategies to combat most stressful events (Folkman & Lazarus, 1980). While adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It also refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (Burton *et al.*, 2013). Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. The level

to which ecosystems, food supplies, and sustainable development are vulnerable or “in danger” depends both on exposure to changes in climate and on the ability of the impacted system to adapt. Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompts them, and their timing, functions, forms, and effects. For this study adaptation refers to alterations of daily livelihoods in preparation for the expected and actual climate change effects.

A number of agricultural adaptation strategies have been adopted by smallholders in order to cope with the stresses of a changing climate. These include on-farm diversification, adoption of water technologies and management, introduction of new crop varieties, and strategies to spread risks across space or time. The availability or suitability of each of these options will differ for individual smallholders depending on regional, local, and farm-level context (Cohn *et al.*, 2017). Aniah *et al.* (2019) defined on-farm adaptation strategies as a chain of practices or strategies carried out by agricultural dependent smallholder farmers on their farm intended to offset the negative effects of ecological and climate change/variability, particularly droughts. Off-farm adaptation strategies are strategies or actions that smallholder farmers carry out outside the farm, that are intended to moderate their vulnerability to negative effects of climate and ecological change/variability, such as food/livelihood insecurity. Adaptation to climate change has the potential to substantially reduce many of the adverse impacts of climate change and enhance beneficial impacts—though neither without cost nor without leaving residual damage (Burton *et al.*, 2013). Aniah *et al.* (2019) identified key coping measures which include, but not limited to, relying on assistance from family and friends, receiving assistances from government, income from off-farm jobs, harvesting wild fruits and game, selling household assets and buying of food. However, Burton *et al.* (2013) asserts that coping measures such as selling household assets, migration of the entire households and decreasing food consumption/changing diets can be damaging.

The most common adaptation strategies used by smallholder farmers in many SSA countries include: planting late or early to avoid drought, planting drought tolerant crops and early maturing crops, planting various crops at different times, using indigenous knowledge and appropriate agronomic practices, planting trees and alley cropping, and dry season gardening and irrigation. Despite these coping and adaptation strategies, smallholders face many barriers to adaptation, including limited economic and financial resources, lack of access to usable information, unavailability of appropriate technologies for different users, credit constraints, lower socio-economic and educational status of users, networks (Foster & Rosenzweig, 2010;

Lemos *et al.*, 2012; Rogers *et al.*, 2009; B. Smit & Skinner, 2002; Zilberman *et al.*, 2012). These constraints can lead smallholders to have lower levels of risk tolerance compared to other farmers, which also influences adoption (Clark, 2002; Zilberman *et al.*, 2012). The uncertainty associated with future climate changes also poses a barrier for the adoption of adaptation measures (Fuss *et al.*, 2015; Vermeulen *et al.*, 2008). The next sub-section reviews the smallholder farmers' decision-making and direct involvement in common bean production.

2.4 Smallholder farmers' decision-making and involvement in common bean production activities at household level

2.4.1 Smallholder farmers' decision-making on common bean production activities at household level

Smallholder farmers' decisions are made in response to and anticipation of climatic and non-climatic dynamics. Due to the complex household decision-making process, an interdisciplinary approach is important to understand the process based on other studies to explore one or few aspects of decision-making. Owing to such understanding of decision-making, four questions are posed to set an enquiry: (1) what response strategies are undertaken by households in rain-fed contexts; (2) who is making what decisions; (3) when do households make decisions and why do they make them (factors affecting decision-making); and (4) how decision-making process evolves (Singh *et al.*, 2016).

The agricultural sector in SSA is dominated by smallholder farmers who depend on land as an important asset for agricultural production. Women are key players in the agricultural sector in this region as they constitute the majority of smallholder farmers, providing most of the labour, and managing a large part of farming activities on a daily basis (FAO, 1995; ILO, 2009). This is especially true in rural communities where agriculture self-employs 56.6 and 53.5 percent of the men and women, respectively, though differences in farming systems, as well as social and cultural institutions, complicate the measurement of gender differentials in crop production (Marinda, 2006). However, despite their importance in the agricultural economy of these countries, development projects focusing on their productive role in farming are yet to be integrated into national agricultural planning and policies (Adeniyi, 2010).

Akinola (2018) found that the major challenge facing women farmers in SSA is poor access to land, due to several formal and traditional rules and that, despite the development of legal frameworks that expand women's property rights, cases of cultural impediments to the exercise of land rights abound in Africa. Lack of land ownership in turn not only makes it difficult for

them to take farm-related decisions, but they also find it impossible to obtain credit to improve crop yield ([Lastarria-Cornhiel, 2006](#)). Land ownership is a critical issue in agriculture because access to other productive resources such as water, irrigation systems, and forest products are tied to land tenure ([Meinzen-Dick, Di Gregorio, Dohrn, 2010](#)). Limited land makes it important for women to take part in decision-making regarding crop cultivation and management. Yet, the diminishing capacity of smallholder agriculture to provide for household needs is being increasingly aggravated by the mounting workload of women, who are also expected to look after their children, cooking and serving meals, feeding, cleaning and physical care ([World Economic Forum, 2020](#)). According to [World Bank \(2008\)](#), low farm productivity has forced rural women to make up for the family's food deficit by working as casual hired labourers on larger farms or by engaging in petty business activities. Despite the large number of women in the farming sector, very few women are involved in agricultural policymaking in SSA countries, even though their empowerment and enhanced participation is essential for the adaption of gender-responsive and participatory agricultural and rural development policies ([FAO & UNDP, 2018](#)).

Traditionally in Africa, men have dominated decision-making on both household matters and crop management ([Enete & Amusa, 2010b](#)), even in areas where women are the largest providers of farm labour. However, this situation is changing in Cameroon and other countries, where men cultivate cash crops such as cocoa and coffee, while women concentrate on growing crops vital for the food security of the household and have little or no say in decisions regarding their crops ([Sikod, 2007](#)). The challenge is that a woman's participation in decisions related to the farm largely continues to be minimal and depends on her ownership of land and access to household assets ([World Bank, 2008](#)). The emerging household strategies to mitigate the constraints imposed variously by market, state failures, social norms and exposure to uninsured risks include embracing the spirit of collective action and encouraging joint decision-making by men and women. Well-informed decisions regarding crop cultivation and management are of great significance for households with limited production resources such as land, labour, and capital. To achieve maximum efficiency and production it is important for both men and women to make educated choices. The noteworthy decisions that affect the fortunes of a smallholder farmer include which crops to produce, how much land to allocate to each crop, and the kind of inputs which will boost crop yield ([Orr et al., 2016](#)). Wise crop management decisions can maximize output and profit despite the limited availability of resources ([Ochieng et al., 2014](#)). It is clear that women are the prime stakeholders in the family and their

contribution to decisions on crop management can be more significant than that of men (Shrestha *et al.*, 1999). However, their voices or opinions are not taken on board where decisions related to crop production are arbitrarily taken by male heads in many agricultural households. Irrespective of the importance of women's inclusiveness in decision-making in the agricultural sector in developing countries, men continue to dominate farm decision-making functions, even in areas where women are the largest providers of farm labour (Enete & Amusa, 2010a).

Okonya *et al.* (2019) affirms that efficiency in smallholder agriculture may be improved through designing better interventions based on understanding the division of labour and decision-making in crop management. Most of the decisions and labour provision during the production of both cash crops (potato and banana) and food crops (sweet potato and cassava) were done jointly by men and women in male-headed households. Higher values for 'credit access', 'land size', and 'farming as the main occupation of the household head' increased the frequency of joint decision-making in male-headed households. A decline in the amount of farm income reduced the participation of men as decision makers. A reduction in total household income and proximity to the market was correlated with joint decision-making. Gender norms also contributed to the lower participation of women in both decision-making and labour provision in banana and potato cultivation. Although a large proportion of decisions were made jointly, women perceived that men participated more in decision-making processes within the household during the production of cash crops (Orr *et al.*, 2016). Intra-household decision-making power is related with the negotiating power of a given household member. This power is dependent on a number of complex factors (factors of production) including access to agricultural land and inputs, training, and financial loans through formal and informal credit institutions (Agarwal, 1997).

Although the dynamics are changing, in Malawi, common bean is considered as a women's crop because: (a) approximately 90 percent of the labour is provided by women, (b) decision-making concerning beans is carried out by women and (c) they are usually more knowledgeable about the crop (Njuki *et al.*, 2011). In southern Africa, groundnut is regarded as a 'women's crop' primarily because much of the labour is provided by women (Tsusaka *et al.*, 2016). The term "women's crops" are a familiar feature in writing about smallholder agriculture in Africa. The term has always been associated with different meanings. Njuki *et al.* (2011) defined women's crops as those crops whose largest share of labour is contributed by women. While Doss (2001) and (Orr *et al.*, 2016) described women's crops as those where women enjoy the

highest level of control over decision-making in various steps of production. Commonly in agrarian communities, women's crops are those that are produced for subsistence purposes; and men's crops are those grown by men for sale. [Doss \(2001\)](#) further likened this to women's responsibility for feeding the family and men's responsibility to provide cash income.

2.4.2 Smallholder farmers' direct involvement in bean production activities at household level

Smallholder farmers' direct involvement in undertaking common bean production activities was believed to be carried out by women as per the definition of beans as a woman's crop. [Nakazi et al. \(2017\)](#), however, found that involvement in bean production activities at the household level is not restricted to women as men also offer support in a number of ways, more especially for those requiring more energy input. Again, irrespective of cropping patterns, activities are done by both men and women, thus, policy inferences relating to bean as purely a woman's crop are misleading; in bean production systems they should be targeted to both men and women. In addition, in respect of perceived farmers' participation, women normally participate more in most of the activities despite men's domination in some. Further, the participation rates are influenced by factors other than gender, i.e. age, intercropping, distance to bean plots, farming as a primary occupation, wealth index, crop attributes, number of times beans are consumed among others. Nevertheless, despite mixed views regarding the dominance of involvement in bean production activities, men's efforts are increasing in activities like weeding, threshing, winnowing and sorting - traditionally considered women's activities.

The topmost five bean production activities in which men reported heavy participation included: site selection, spraying against pests and diseases, bush clearing, fertilizer application and harvesting beans. Thus, women have significant participation in bean production activities of planting, weeding, harvesting, transporting beans from the garden, threshing beans, winnowing, sorting and post-harvest handling and storage of beans. Women's greater participation in planting and weeding activities indicates their significant concern for better and vigorous growth and development of beans at early growth stage. This corroborates with the findings of [Chayal et al. \(2013\)](#) who considered weeding one of the major activities in which women greatly participate. Men's higher participation in site selection could indirectly reveal that they are the landowners who require women to seek permission to plant beans.

2.5 Subjective and objective approaches to understanding smallholder farmers' resilience to climate variability and change

Numerous frameworks and approaches are proposed for the measurement of household resilience which mostly concentrate on 'objective' indicators by identifying the key socio-economic variables and other capitals that support people's livelihoods (Bahadur *et al.*, 2015). The selection of these variables is often value-laden and contested as they typically require large and robust socio-economic datasets, which are in many cases not available, more especially in the context of developing countries (Bahadur *et al.*, 2015; Carpenter *et al.*, 2001). However, a corresponding approach which can add value to objective forms of measurement in assessing household resilience has generally been overlooked: 'subjective' household resilience (Jones & Tanner, 2015).

2.5.1 Objective approach

Objective approaches commonly refer to aspects of measurement that are independent of the subject's judgment. In respect of resilience, this normally relates to approaches that use descriptions which are externally defined (i.e., defined by the evaluator rather than the people or communities being assessed). It also refers to approaches where measurement takes place via external observation, or use of questions that solicit little, if any, judgment on the part of the subjects being evaluated. Objective approaches to resilience measurement remain the norm across both research and practice (MEL-CoP, 2016; Schipper & Langston, 2015). As such, they command a large level of our understanding of the processes that mould societal responses to climate variability and change.

Systems which rely on climate and natural resources to undertake their core functions suffer greatly from the impacts of climate variability and change. Increased variations in weather patterns affect smallholder production systems by reducing their crop and/or livestock productivity. This is due to increased biotic (pathogen and pest pressure) and abiotic (amount of rainfall, rainfall onset time, rainfall distribution and extreme events) stresses (Perez *et al.*, 2015). The exposure, sensitivity and lack of adaptive capacity render the system vulnerable, directly or indirectly affecting smallholder farmers whose livelihoods are dependent on agriculture which is threatened by the impacts of climate variability and change. Hence, building farmers' resilience is important for addressing the challenges faced by households as a result of the changing climate (Tambo, 2016). A resilient system exhibits characteristics that

are key to withstanding and dealing with surprising and unexpected stresses that can disturb the normal functioning of the system (Table 2.1).

Table 2. 1: Characteristics of a resilient system - adopted from Perez *et al.* (2015).

#	Characteristics of a resilient system (indicators)	Resilience system
1	<i>Livelihood diversity</i> Diverse economic opportunities Off-farm economic options (e.g., migration, remittances) Level of technology Food security Dependence on diverse natural resources Population growth rates	Enough food and income mainly from farm Off-farm employment and access to cash. High technology levels Uncommon long hunger periods Low dependence on natural resources Low perceived population growth
2	<i>Assets</i> Wealth, access to credit Strength of natural resources Soil quality Schools	Wealth, some access to microfinance. No natural resources encroachment and depletion Uncommon soil degradation and erosion Availability of primary schools
3	<i>Social and economic equity within community</i> Access to resources for individuals Distribution of wealth and assets Access to land Access to technology and inputs Access to agricultural training and technical support	Equal access resources Equitable wealth and asset share Equal access to land. Equal access to improved technology or equipment, manure or labour Equal access to agricultural training and services
4	<i>Community ownership of natural resources, and voice in relevant policies</i> Communities' shared rights and responsibility for resource management Government recognized community control over natural resources	Equal rights for resource use and management Government empowers communities in managing natural resources
5	<i>Community capacity to organize</i> Cooperation and coordination based on trust, norms and networks Strength of community organizations Strength of organizations outside the community Participation in community decision- making Community access to external resources and knowledge	Internal cooperation albeit by sex Active community organizations Active outside organizations support provision Equal rights for decision-making Access to external resources
6	<i>Effective governance</i> National policies promote natural durable resource management Local governments capable of planning to prevent and respond to risks Local organizations are flexible and respond to local realities Local organizations capable of planning for preventing and responding to risks	Policies encouraging sustainable land use and conservation of natural resources. Government risk management capability Organizations' flexibility to respond to local needs Local organizations capability
7	<i>Combining different types of knowledge</i> Indigenous local ecological knowledge used in management of resources Combined local and scientific knowledge	Use of indigenous knowledge Significant combination of knowledge
8	<i>Capacity to learn</i> Education, skills, knowledge levels	Basic education levels

The measure of smallholder farmers' resilience to climate variability and change has been adopted from the resilience framework developed by (FAO, 2010) designed to capture household food insecurity. The framework is known to be flexible and has been adopted in climate resilience research through the inclusion of other indicators such as knowledge of climate change and access to early warning system services which are not captured in the framework of resilience to food insecurity (Tambo, 2016). The FAO resilience framework consists of the following components: income and food access (IFA), assets (A), access to basic services (ABS), social safety nets (SSN), and stability (S). An inclusion of adaptive capacity (AC) and other climate related indicators makes it appropriate to measure resilience to climate change (L Alinovi et al., 2010). With regards to measuring the components of resilience indicators, a number of variables are directly measured to establish the values of the respective components in which the component indicators are latent in nature.

Income and access to food (IFA) as a component is normally estimated using the following indicators: per capita income, household food insecurity access scale (HFIAS) and dietary diversity score (DDS).

Per capita income - annual per capita household income (MK/person/year).

HFIAS - this captures household responses to nine food insecurity perception questions (Salvador Castell et al., 2015).

Dietary diversity - Household Dietary Diversity Score (HDDS). This estimates household daily consumption of 12 food groups (cereals, roots and tubers, vegetables, meat, poultry, offal, eggs, fish and seafood, pulses/legumes/nuts, milk and milk products, oil/fats and sugar/honey) (Guiding Framework, 2017).

Assets form an important part of household's capital and serves as a coping mechanism in times of hardships. Estimation of smallholder assets usually involve taking stock of physical capital (housing, consumer durables), financial/productive capital (labour security, productive durables, transfer/rental income), human capital (education) and social capital (household and community) (Moser & Felton, 2009).

Access to basic services (ABS) - better access to public/basic services affects household's capacity to manage risks and respond to crisis. The following ABS indicators are considered for its estimation:

- ❖ *Source of water* - distance to nearest source of water (km).
- ❖ *Health service* - distance to nearest health care services (km).
- ❖ *All-weather road* - distance to nearest all-weather road (km).
- ❖ *Electricity* - household has access to electricity.
- ❖ *Access to telecommunication* - household has access to a telephone.
- ❖ *Access to credit* - a household member receives credit (in cash or in kind) from any source.

Social safety nets (SSN) - many households depend on assistance from international agencies, charities and non-governmental organization as mitigation measure to shocks. The estimation of this variable involves:

- ❖ *Safety nets* - number of safety nets programmes in which a household participates.
- ❖ *Group membership* - a household member belongs to a group or an association.
- ❖ *Amount of cash and in kind assistance* - MK/person/day.
- ❖ *Quality of assistance* - ordinal scale from 1-4 (highly satisfied, satisfied, not satisfied and highly unsatisfied).
- ❖ *Frequency of assistance* - times assistance was received in the last six months.
- ❖ *Overall opinion of targeting* - assistance targeting the needy; some not needy; or without distinction.

Stability (S) - the following indicators estimates stability:

- ❖ *Professional skills (counts)* - the number of household members with at least a diploma is used as a proxy.
- ❖ *Educational level (continuous)* - this measures the average number of years of schooling of household members.
- ❖ *Employment ratio* - a ratio of employed household members to the household size.
- ❖ *Number of household members to have lost jobs (count)* - the number of household members to have lost their employment in the last six months.
- ❖ *Income stability (increased; same; decreased)* - this estimates income variation over the last six months.
- ❖ *Assistance dependency (ratio from 0-1)* - a ratio of monetary value of assistance to total income.

- ❖ *Assistance stability (increased; the same; decreased)* - a variation in the quality of assistance over the last six months.
- ❖ *Health stability (1-8)* - estimates the number of institutions providing medical care.
- ❖ *Education system stability (increased; the same; decreased)* - a variation in the quality of education over the last six months.

Adaptive capacity (AC) - this indicates a household's capacity to cope with and adapt to a certain shock and enable normal functioning. Adaptive capacity is estimated using the following indicators:

- ❖ *Diversity of income sources* - number of household income sources.
- ❖ *Dependency ratio* - ratio of members aged below 15 and above 64 to those aged 15-64.
- ❖ *Adaptation strategies* - number of available climate change adaptation strategies.
- ❖ *Early warning systems* - households receives early warning system notices.
- ❖ *Knowledge of climate change* - household members are aware of climate change and its impacts.
- ❖ *Savings* - household has savings with a bank or saving group.

2.5.2 Subjective approach

Subjective resilience is defined as how people perceive their level of resilience to specific external shock and stresses at household level (Jones & Tanner, 2015). Contrary to the objective quantification of resilience which uses a top-down approach, subjective resilience supports more structural elements instead of those based on human agency. These may be more difficult to understand and measure, and under-value how people evaluate their own lives, often requiring value judgements to simplify the complex nature of resilience across multiple contexts (Diener et al., 2012; Tanner et al., 2015). Subjective measure uses a bottom-up approach built on the premise that people are better placed in terms of how they recognize the factors that add to their ability to predict, cushion and adapt to disturbance and change. Subjective household resilience, therefore, relates to an individual's cognitive and affective self-assessment of their household's capabilities and competences in responding to risk (Jones & Tanner, 2015). Subjective resilience can be ascribed to two noteworthy factors. Firstly, it relates to the idea that tangible objective elements are not the only relevant elements, and that wider social, cultural and psychological elements are equally fundamental elements (Adger et al., 2013). Elements of subjective resilience comprise a range of issues which include perception of risk, sense of place, beliefs and culture, social norms, social cohesion, power and

marginalisation, and cultural identity (Adger *et al.*, 2009; Clayton *et al.*, 2016; Grothmann & Patt, 2005). Secondly, it relates to the notion that individuals assess how resilient they are or how resilient others around them are, whether at the personal, household or community level (Marshall, 2010). Its complementarity to the objective measure of resilience is vital as it offers a number of merits which in no way are limited to:

First, it takes advantage of the fact that in an event of disturbance and change, based on their capabilities and capacities, people are aware of how to deal with the situation (Nguyen & James, 2013). Hence, it trusts people's self-evaluation and considers what characteristics are the most important.

Second, subjective measures of resilience help to reduce the headache of selecting indicators. A vast number of indicators are used in different methods for measuring objective resilience. The Sustainable Livelihood Framework's five capitals (Adriana Keating, Karen Campbell, Reinhard Mechler, Erwann Michel-Kerjan., 2014; Elasha *et al.*, 2005; Lockwood *et al.*, 2015; Uy *et al.*, 2011), variants of the Human Development Index and many other individual frameworks (Fox, 2012; Ifejika Speranza *et al.*, 2014; Pasteur, 2011) including resilience framework to food insecurity (FAO, 2010), each use their own set of indicators to characterise livelihood resilience.

Third, as opposed to objective resilience measure which requires large socio-economic datasets, subjective resilience measure allows exploration of insights in contexts where accurate and large socio-economic datasets are inadequate. Lastly, resilience is greatly fashioned by sociocultural and psychological factors such as risk perception, cognitive barriers and personal or cultural values, which can each translate into a key role in determining whether adaptation is required, or whether people have access to vital resources in times of need (Jones & Boyd, 2011; Kuruppu & Willie, 2015). It is clear that using these two approaches simultaneously could yield well-informed results and reduce areas where an individual approach has limitations.

2.6 Theoretical consideration of resilience to climate variability and change in smallholder farming

Farming systems in resilience literature is used interchangeably with agro-ecosystems and also considered as social-ecological systems (SEs) which encompass both biophysical and human components (Keating & McCown, 2001). A farming system is a unit of analysis that goes beyond individual farm systems as it comprises multiple diverse, individual, but interacting, individual farms (Giller, 2013). The varied production and social structures of individual farms similarly implies the varied ability of smallholder farmers to respond to climate variability and change, hence, different farm-scale climate impacts (Antwi-Agyei *et al.*, 2012). In the context of current and/or future climate variability and change, supporting individual farm resilience forms a wider goal to strengthen the resilience of smallholder farming systems. In SEs setting, resilience can be looked at in two folds. First, specified resilience which understands the systems' resilience (or part of a system) in respect to a particular shock, stress or perturbation, and second, general resilience which does not define a particular part of the system or identify specific shocks (Folke *et al.*, 2010). However, specified resilience is not without limitations as concentrating on a specific shock or part of a system can leave other shocks emerging strongly to disturb the systems and cause loss of resilience. It also requires that knowledge of a specific shock or the ability to predict nature of the specific shock is clear which stand as a problem in light of increasingly variable, dynamic and uncertain climate conditions (Tyler & Moench, 2012). Therefore, building general resilience is considered necessary in coping with, and adapting to, changing and varying climate.

In general, resilience is built on three strategies which include reduced exposure, reduced sensitivity, and increased adaptive capacity (Gitz & Meybeck, 2012). Reducing exposure implies reducing the chances of a certain risk occurring, as well as its severity. This strategy makes a distinction between climatic and non-climatic shocks where it may be possible for some non-climatic shocks to reduce the likelihood of their occurrence and severity at the farm level, whereas for climatic shocks this may be practically difficult. Reducing sensitivity of the farm to shocks involves identification of the possible risk and developing response mechanisms to reduce the impacts. For instance, sensitivity to drought can be reduced by developing and using drought-tolerant varieties. This strategy requires that the likely risks are measurable and identifiable in advance; however, this is not always possible at farm level. Increasing adaptive capacity implies enhancing the capacity of farmers to respond promptly and effectively to the effects of climate change, for instance, through the use of novel management practices and

innovative technologies (Freduah *et al.*, 2019). Farmer adaptive capacity relates to management options aimed to manage climate change and with improving decision-making under uncertainty (McCarthy *et al.*, 2018).

Regardless of its popularity, the resilience concept is not without criticisms (Brown & Westaway, 2011; Moser, 2008; Walker & Cooper, 2011). One key criticism is the continuous presentation of resilience as a position attribute while overlooking the notion that a resilient system may sometimes bounce back to an undesirable state (Carpenter & Gunderson, 2001; Walker *et al.*, 2006). Therefore, defining resilience as robustness or ability to bounce back to a prior state can be confusing and allow unsustainable or socially unjust practices to continue (Pelling, 2011). Further, resilience thinking has been criticized as having shortfalls to satisfactorily capture social dynamics related to power and agency (Olsson *et al.*, 2014). This is because agency, the ability of individuals to exercise a degree of choice or autonomy over their own lives, is often veiled in resilience assessments that focus on a household, community or system scale (Cutter *et al.*, 2008). This can lead to contradiction in the ways individual households act to strengthen their overall resilience at the detriment of another individual's well-being (Coulthard, 2012).

Regardless of the absence or presence of criticisms levelled against resilience thinking, the “Holocene” has gone -an era when humanity had lived in a relatively stable climate for the last 10,000 years (Steffen *et al.*, 2007). This era allowed agriculture and all major human activities including civilizations to develop and flourish. As time is elapsing, the likelihood is higher that the future of human well-being may be seriously compromised if the critical threshold that tips the earth system out of this stability domain is passed (Rockström *et al.*, 2009). It is unquestionable that the integrated human-earth system would sink into a radically different basin of attraction if the current development paradigms and patterns continue (Steffen *et al.*, 2007). This calls for novelty and innovation in trying to prevent such a detrimental critical transition. Insightful adjustments in society are likely to be required to maintain the Holocene stability domain. Unfortunately, resilience of behavioural patterns in society is so large that it poses a serious hindrance for preventing loss of Earth System resilience. SES resilience that contributes to Earth System resilience is needed to remain in the Holocene state (*ibid*).

General resilience shares a reasonable number of similar attributes with transformability, including high levels of all forms of capital, diversity in landscapes and seascapes and of institutions, actor groups, and networks, learning platforms, collective action, and support from higher scales in the governance structure. Transformational change often involves changes in

perception and meaning, social network configurations, patterns of interactions among actors including leadership and political and power relations, and associated organizational and institutional arrangements (Folke *et al.*, 2009; Huitema & Meijerink, 2009; Smith & Stirling, 2010). A resilience perspective stresses an adaptive approach, expediting different transformative experiments at small scales and allowing learning from others and new initiatives to emerge, but only restricted by avoiding trajectories that the SES does not desire to follow, especially those with recognised thresholds. The first part of this process is much the same as that proposed in the socio- technical transitions literature, which encourages arenas for safe experimentation (Fischer-kowalski & Rotmans, 2009; Loorbach, 2007). However, where the transition model then determines the new goal and adopts a particular process for reaching it, a resilience approach would allow the new identity of the SES to emerge through interactions within and across scales.

In 1970s, land degradation reached unsustainable levels and resulted in declining agricultural productivity in several Latin American countries. Due to this, some farmers started experimenting with unusual (unconventional) land management methods. To be specific, low-till alternatives to ploughing which are based on low disturbance of the land to enhance soil organic matter and fertility (Derpsch & Friedrich, 2017). Individual farmers and researchers in Brazil, Paraguay and Argentina, were reported to be the first to pursue such responses to the land productivity crisis and subsequent social crisis of deteriorated livelihoods through experimentation with new innovative breakthroughs in technologies. This involved the shift to no-tillage methods requiring major changes in land management practices, such as weed management, mulch-farming and green manuring techniques, as well as new machines for direct planting. This small-scale experimental learning approach caused a transformation of the whole farming system. Currently, more than 25 million hectares of agricultural land is under no-tillage in Brazil alone, and in Latin America the transition from conventional plough-based agriculture to no-till systems has reached a scale where one can talk of an agrarian revolution or a social-ecological transformation (Fowler & Rockstrom, 2001). Another ingredient to resilience thinking besides transformability is adaptability. Adaptability places its emphasis on the capacity of an SES to adjust its responses or actions to changes and disturbances through learning, experience, and knowledge, and continue developing within the stability sphere or basic desirability (Berkes *et al.* 2003). Adaptability has been defined as "the capacity of actors in a system to influence resilience" (Walker *et al.*, 2004). Thus, adaptive capacity maintains certain processes despite changing internal demands and external forces on the SES (Carpenter

& Brock, 2008). By contrast, transformability has been defined as "the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable" (Walker *et al.*, 2004).

Based on the understanding of adaptability and transformability as key ingredients to resilience thinking, resilience is beyond being persistent or robust to disturbance. It is also about the opportunities brought about by disturbance and recombination of developed structures and processes, regeneration of the system and emergence of new trajectories. In this sense, resilience provides adaptive capacity (Smit & Wandel, 2006) that allow for continuous development, like a dynamic adaptive interplay between sustaining and developing with change. Too much of either will ultimately lead to collapse. It does not imply that resilience is always a good thing. It may prove very difficult to transform a resilient system from the current state into a more desirable one (Gunderson and Holling, 2002; Scheffer *et al.*, 2001; Walker *et al.*, 2004). Adaptive processes that relate to the capacity to tolerate and deal with change emerge out of the system's self- organization. Furthermore, the dynamics after a disturbance or even a regime shift is crucially dependent on the self-organizing capacity of the complex adaptive system and the self-organizing process draws on temporal and spatial scales above and below the system in focus (Gunderson and Holling, 2002; Nyström & Folke, 2001). This is why the concept of resilience in relation to social–ecological systems incorporate the idea of adaptation, learning and self-organization in addition to the general ability to persist disturbance. Inspired by a systemic conceptualisation of resilience and especially of complex adaptive systems, resilience has moved from the core idea of 'resisting and recovering' into 'adapting'; and from 'stability' to 'change' (Longstaff, 2015; Pelling, 2003).

2.7 Empirical substantiation of resilience to climate variability and change, in smallholder farming

There is a vast number of studies on resilience to climate variability and change in smallholder farming systems in developing countries. Empirical results indicate that resilience of smallholder farmers to climate change is influenced by several factors including but in no way exhaustive: gender, education, financial assistance from family and friends, institutions, cooperatives, and government assistance (Maltou & Bahta, 2019).

Banda *et al.* (2016); and (Maltou *et al.* (2019) found a negative correlation, and significant influence, between gender and resilience concluding that male-headed farming households were more likely to be less vulnerable to agricultural drought compared to female-headed farming households. Again, Mekuyie *et al.*'s (2018) study regarding the resilience of pastoralists to climate change and variability in the Southern Afar region in Ethiopia found that female-headed households were less resilient than male-headed households to climate variability and change. Similarly, studies by Perez *et al.* (2015) found that women have less access to common property resources than men, i.e., land, and women's land is of poorer quality and their tenure system is less secure. Women engage in mutual insurance and risk-sharing networks, and benefit from non-agricultural services provided by social support institutions external to the village. Moreover, there are a massive anti-women biases in legally registered public and private external organizations that nurture agriculture and livestock production. These have tended to provide support predominantly to men. Such behaviours leave women vulnerable, and hence, less resilient to the changing climate. In contrast, Andersen & Cardona (2014) and Jiri *et al.* (2017) found insignificant relationships between the gender of a farming household and resilience to agricultural drought.

Ajibade *et al.*'s (2013) study on urban flooding and patterns of vulnerability and resilience among women in Lagos, Nigeria found that, in general, women expressed no concern about gendered vulnerability to flooding as most believed flood impacts were gender neutral. They further found that women in low-income neighbourhood recorded higher impacts and slower recovery compared to other social categories of women and men.

Education as a determinant of farm resilience has mixed results in literature; some studies show no influence, while others show positive or negative influences. Maltou & Bahta (2019) found that the more educated the farmers are, the less likely they are to enhance resilience to agricultural drought than the non-educated farmers. Similar results were attained by Andersen & Cardona (2014) who found that increasing a farmer's years of formal education by one unit,

results in a 0.365 decrease in farming household resilience and conclude that education has a very small, barely significant, effect on resilience. In the same vein, [Banda et al. \(2016\)](#) and [Jiri et al. \(2017\)](#) found no significant influence of education level of the household head on the adaptation to climate change.

On financial assistance from relatives, [Andersen & Cardona \(2014\)](#); [Banda et al. \(2016\)](#); and [Maltou & Bahta \(2019\)](#) found that farm households that receive financial assistance from friends or relatives tend to be resilient compared to households that do not have any financial assistance from immediate family members living outside the households. The more the farming household receives financial support from relatives the better its chance of being resilient to agricultural drought.

On institutions, studies by [Jiri et al. \(2017\)](#) found that farming households' access to any form of credit or assistance from other institutions such as agricultural private organisations or banks has a positive influence on the resilience to agricultural drought. Hence, greater access to institutions by farming households increases the likelihood of enhancing their resilience to agricultural drought compared to those that do not have access to credit or any other form of credit.

On cooperative membership, studies by [Keil et al. \(2008\)](#) found that farming households that are part of a cooperative are most likely to be resilient to agricultural drought because they are able to assist each other, share information or knowledge, and are able to buy inputs in bulk.

On government assistance, they found a significant negative relationship between government assistance and farm household resilience to agricultural drought particularly due to late provision of the assistance. However, timely receipt of assistance by farm households results in greater likelihood of the household being resilient to agricultural drought. Furthermore, government assistance can also include informing communities about weather predictions, provide training during agricultural drought periods and regular farm visits by extension officials. [Jiri et al. \(2017\)](#) argued that access to extension information significantly affects the farmers' decision to adapt to climate change. This means that farming households with government assistance (extension officials) are expected to be more resilient to agricultural drought.

According to [Maltou & Bahta \(2019\)](#), other variables that can be used to determine farming household resilience to agricultural drought, though not significant in their study, include the following: age, marital status, funding, community collaboration, other water sources, neighbour assistance, number of livestock, other assets, coping strategies, prior knowledge,

enough support, farming experience, drought response, sustaining natural resources and number of household members. However, [Mekuyie et al. \(2018\)](#) found that the resilience of pastoralists to climate change and variability is significantly enhanced by improving factors such as livestock assets and productivity, social safety nets, access to market, credit, extension services and education, improving irrigation crop farming, and providing farm inputs.

In addition to the above determinants, [Maltou & Bahta \(2019\)](#) and [European Union, \(2018\)](#) found that insurance is a key factors in enhancing agricultural drought resilience because any financial damage does not turn into long-term economic damage as can be compensated for though rarely purchased by households because of the expense.

A study by [Kangogo et al. \(2020\)](#) on determinants of farm resilience to climate change identified entrepreneurial orientation (as a farmer psychological characteristic), membership in farmer organizations, and the nature of farmer–buyer relationships as determinants affecting farmer adaptive capacity and there by farm resilience.

Results of a study by [Tambo \(2016\)](#) on adaptation and resilience to climate variability in Ghana show that increasing farmers' knowledge of climate change, as well as building the capacity of extension agents to deliver information on climate change and appropriate adaptation measures, are key to successful adaptation. The results further highlight that a combination of autonomous adaptation measures would enhance resilience, such as altering the timing of planting, use of drought tolerant and early maturing crop varieties, and switching to crops that are less sensitive to climate stress.

[Makate et al. \(2019\)](#) study found that improved farmer education and access to key resources (land, finance, extension, labour etc.) has the potential to improve the adoption of a combination of beneficial synergistic climate-smart agriculture (CSA) innovations, such as drought tolerant maize, improved legume varieties and conservation agriculture. Such innovations offer superior benefits towards adapting agriculture to climate variability and change as they impact positively on crop productivity and income which helps to increase the resilience of smallholder farmers to climate variability and change.

[Hang et al. \(2016\)](#) identified factors contributing to household-resilience capacity to farming risks in clam farming in Thai Binh province, Vietnam. They found household resilience capacity explained by 66 percent of variance of resilience among households including: farmer's ability in acquiring experiences from past failures and harnessing new prospects; farmer's perception toward clam farming risks and its impacts; farmer's assurance about

financial muscle and incomes from diversifying activities which can be used to invest in clam farming.

[Jiri et al. \(2017\)](#) study on building climate change resilience through adaptation in smallholder farming systems in semi-arid Zimbabwe found that better adaptation abilities were positively related to households' increased access to climate information through extension services. Also, farmers in the lower age bracket were likely to adapt to climate change because of their greater flexibility to adopt new techniques and their access and use of modern information and technology. Further, larger households were found to have higher chances of adapting owing to most adaptation strategies being labour demanding. Also, possession of livestock and access to credit significantly enhanced households' adaptation. Intriguingly, households with higher farm income have fewer incentives to adapt as their current farming practices might already be optimum.

2.8 Conceptual framework

Based on the understanding gained from the summary of the literature reviewed in preceding section, the entry point to this work's conceptual framework involves listing the core elements of disaster resilience, factors affecting the resilience of a system, perceptions and household decision-making. Finally, the framework will try to explore the interaction of these elements, farm household perceptions of climate variability and change and decision-making.

Using the core elements of climate resilience (context, disturbances, capacity to deal with disturbances, and reaction to disturbance) and drawing from the DFID resilience framework, together these elements form a framework which can be used to examine different kinds of resilience (for example, of growth or governance systems) and help determine the level of resilience that exists ([DFID, 2011](#)). Clear contextualisation of resilience is always important thus allowing for an articulate answer to the question 'resilience of what?' Resilience can be identified and supported in a social group, socio-economic or political system, environmental context or institution. Each of these systems will show greater or lesser resilience to natural or man-made disasters. Differentiation of the significance of resilience for different social groups, resources and institutions across a range of different contexts require more work. This study answers the question of 'resilience of what?' as resilience of the 'common bean smallholder farm household'. Having determined the resilience of what, the next step is to understand the disturbances faced thereby addressing the question 'resilience to what?' These disturbances are

normally explained in two forms e.g. shocks and stresses. Herein, shocks are sudden events that impact on the vulnerability of the smallholder farm households and their components. Disaster-related shocks can come in different forms (e.g. outbreaks, weather-related and geophysical events including floods, high winds, landslides, droughts or earthquakes) and strike at different levels. There can also be conflict-related shocks such as outbreaks of fighting or violence, or shocks related to economic volatility. However, conflict related shocks such as outbreak of fighting or violence are beyond the scope of this study. Stresses are long-term trends of (e.g. natural resource degradation, loss of agricultural production, urbanisation, demographic changes, climate change, political instability and economic decline) that destabilise the potential of a given system or process (smallholder farmers) and increase the vulnerability of actors within it. Of course, smallholder farm households in different countries often face multiple interconnected shocks and stresses.

When smallholder farmers are impacted by shocks and stresses, the next step is to understand their capacity to deal with the disturbances. Drawing from the vulnerability concept, systems or smallholder farmers' capacity to deal with disturbances is based on the levels of exposure, the levels of sensitivity and adaptive capacities. Exposure to risk is an assessment of the magnitude and frequency of shocks or the degree of stress. For example, exposure to conflicts could be measured by the size and frequency of violent events caused by conflict or fragility, or the extent of political instability in other factors such as rule of law or human rights. Sensitivity is the degree to which a system will be affected by, or respond to, a given shock or stress. This can vary considerably for different actors within a system i.e. gender. For example, women accounted for up to 80% of those who died during the 2004 Indian Ocean tsunami ([Frankenberg et al., 2011](#)), and death rates among women were almost four times higher than those among men in the 1991 Bangladesh cyclone ([Begum, 1993](#)). Limited mobility, skills set and social status exacerbated sensitivity to the shock. The adaptive capacities of actors – individuals, communities, regions, governments, organisations or institutions – are determined by their ability to adjust to a disturbance, moderate potential damage, take advantage of opportunities and cope with the consequences of a transformation. Adaptive capacities allow actors to anticipate, plan, react to, and learn from shocks or stresses. Capacity to deal with disturbances may lead to either reduced or increased exposure, sensitivity or adaptive capacity and essentially translates into how the system reacts to the disturbances, i.e., survive, cope, learn and transform. Sensitivity and adaptive capacity are determined by the pool of assets and resources that can be mobilised in the face of shocks and stresses. Assets and resources can be

social, human, technological, physical, economic, financial, environmental, natural, and political. Whether a system or a process is resilient is a function of its sensitivity and adaptive capacity. The other side to this is vulnerability - the degree to which a system is susceptible to, or unable to cope with, the adverse effects of shocks and stresses. Considering the capacities of smallholder farmers to deal with shocks and stresses, the reaction to a shock or stress might be a 'bounce back better' for the system or process concerned. In this case capacities are enhanced or sensitivities and exposures are reduced, leaving a system that is more able to deal with future shocks and stresses. An alternative reaction might be a 'bounce back' to a normal, pre-existing condition, or to 'recover, but worse than before' – the latter resulting in reduced capacities. In the worst-case scenario, the system or process might not bounce back at all, but 'collapse', leading to a catastrophic reduction in capacity to cope in the future.

A set of resources and assets can be utilised in the face of a stress or shock and are key determinants of exposure, sensitivity and adaptive capacity. Ensuing the sustainable livelihoods framework, resilience enhancing activities can be usefully classified using the following assets; social, human, physical, financial, and natural. However, the relationship between, for example, an environmental shock or stress and an environmental resilience intervention is not linear. Instead, as in the livelihoods approach, the full range of asset types needs to be considered when considering a resilience intervention. By classifying different interventions by type and level of operation, it is possible to map the existing portfolio of disaster resilience activities in a country or a region.

Therefore, this conceptual framework (Figure 2.2) has been proposed around the social-ecological system concept which integrates ecosystems and human society with reciprocal feedback and interdependence (Folke *et al.*, 2010). Increased reciprocity helps motivate collective action to manage the commons by influencing social norms and individual decision-making (Ostrom, 1990). Reciprocal relationships between people and the environment are based on ethical obligations to care for, restore, and protect the land and resources that, in turn, support their existence (Diver *et al.*, 2019). The framework empirically explored smallholder farmers' perceptions of climate variability and change, effects of shocks and stresses on their livelihoods, use of adaptation strategies to climate variability and change, decision-making on production activities in the face of climate variability and change, socio-economic factors defining resilience, action taken by smallholder farmers to curb the impacts of weather changes. The aspects of resilience science though mentioned at some point are beyond the scope

of this study. Smallholder farm households are expected to be significantly affected by climate variability and change. Hence, understanding farmers' perception of shocks and stresses on account of climate variability and change can help to reduce the effects of the disturbances and improve the capacity to deal with them. In the long run, this may improve the reaction to disturbances. This framework is built to understand systems' performance after gender inclusion and decision-making in functions to improve on the capacity to deal and react to the disturbances.

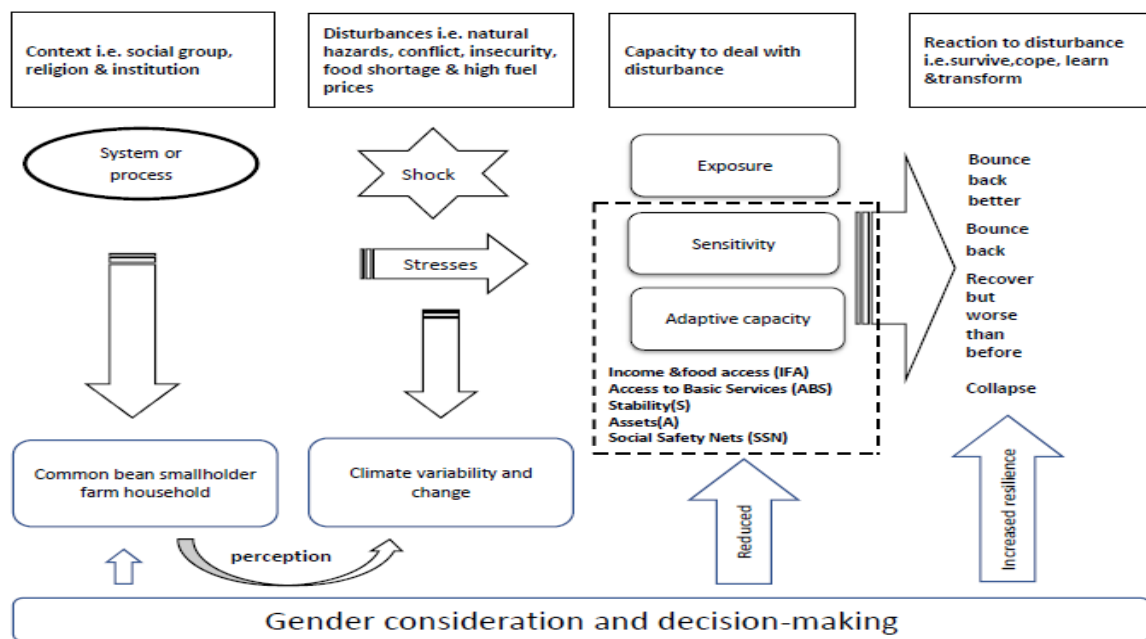


Figure 2. 2. Conceptual framework

2.9 Chapter summary

Some of the key concepts of the study, namely smallholder farmers, perception, climate variability and change, climate resilience, gender, objective and subjective approaches to understanding resilience are defined in this chapter. Subsequent to the various definitions of different concepts used in this research, this study defines smallholder farmers as ; farmers who operate on limited resources, low labour force, low production, low access to information, low confidence in production activities due to low resource endowment, basically produce for consumption to just meet household needs for part of the growing calendar and run out without enough to feed their households in the other half of the growing calendar and are often excluded from the markets. This study further understands perception as an outcome of individual's interpretation/attitude from the understanding of the environment. This study uses the definition three of climate change by [Werndl \(2016\)](#), which states that climate change is the finite distribution of climate variables relative to the regime of varying external conditions. In this study, gender is defined as an association of males and females in how they undertake farming activities at household level. Finally, this study understands subjective resilience as personal expressivity of how they stand effects of the changing climate, while objective resilience definition is adopted from the definition by [Alinovi et al. \(2010\)](#) which emphasis on socio-economic variables. A review of some empirical literature on resilience to climate variability and change in smallholder farming and a gender perspective are also presented. This chapter also reviews some theoretical literature on factors driving farmers' perceptions of climate variability and change, knowledge, response and impacts of climate change, decision-making, and direct involvement on production activities at farm level. The literature has shown that, in general, farmers' perceptions, knowledge and impacts have potential to drive farmers to respond to the changing climate on the way to resilience building given the capabilities and capacities in smallholder farming, especially in SSA. Several studies show that resilience of the smallholder farming to changing climate is significantly affected, either positively or negatively, by factors such as gender, education, institutions, age, awareness or knowledge, experience, access to information, and government and other forms of assistance. Other factors affecting resilience of smallholders to climate change are entrepreneurial orientation, membership to farmers' organizations, farmer-buyer relationship, safety nets and provision of inputs. It should be noted that these are more of an objective approach to measuring farmers' resilience though overlaps with subjective approach at certain times. Owing to some limitations within an objective approach, there is growing enthusiasm for complementary use of the two

approaches. Based on the reviewed literature, the understanding of the concepts and terms around this research, coupled with theoretical consideration and empirical substantiation a strong basis is constructed to address the research objectives. The next chapter discusses methodology used in this study.

CHAPTER 3. METHODOLOGY

3.1 Introduction

Studying smallholder farmers' resilience to climate variability and change faces a major methodological challenge of ensuring that simple and operational tools are used to address its complexity (Douxchamps *et al.*, 2017). Smallholder farming in Malawi is heavily dependent on rain-fed production systems which tends to be seriously affected by extreme weather events as a result of varying and changing climate. Investigating farmers' perceptions, knowledge, and impacts of climate variability and change offers a chance to explore action taken. In addition, understanding participation in decision-making, and direct involvement on farming activities in the face of climate variability and change meant that the researcher was capturing information regarding translation of perceptions and knowledge into response. Understanding resilience requires a range of variables including socio-economic, political and account for spatial and temporal variables at multiple scales. A mixed methodological approach was adopted which comprised both qualitative and quantitative data collection, and include more systematic indicators as well as indicators of stability and shocks. In addition, the approach helped to adequately capture the perceptions, decision-making on participation and direct involvement as a pathway to climate resilience in smallholder farming in Malawi.

3.2 Research approach and epistemology

The thematic areas of this study and their respective research questions were categorized into two overarching themes, in respect of the understanding of target respondents. This was done in order to achieve the most suitable and effective methodology for data collection. Firstly, the study focused on farmers' perceptions of climate variability and change as a pathway to resilience. Secondly, the study focused on farmers' participation in decision-making on farming activities and how the first and second theme relate to climate resilience in smallholder farming.

Research on human-environment interaction builds its methodological approaches from multidisciplinary fields i.e., environmental economics, political economy, cultural ecology, and international development. Therefore, the researcher has a wide range of methodological approaches to learn from and shape the design of their research methods. The research evolving

from such multiplicity of methodological approaches result into mixed methods¹ (Tashakkori & Creswell, 2007:4). The main rationales or benefits for undertaking a mixed methods study are as follows: triangulation, completeness, off-setting weaknesses and providing stronger inferences, answering different research questions, explanation of findings, illustration of data, and hypothesis development and testing (Bryman, 2006). Doyle *et al.* (2009), argued that although it is clear that a mixed methods approach has much to offer a researcher, there have been criticisms of its use. Many of these criticisms focus on the incompatibility thesis, that is, the belief that quantitative and qualitative research methods cannot be mixed in a single study as they have such different ontological and epistemological origins. However, despite these criticisms, Sandelowski (2000), emphasised that mixed methods research is now viewed as the third methodological movement and as an approach that has much to offer. They further assert that, the purpose of mixing approaches is to afford opportunity to gain a more complete understanding of research problems. The researcher used the mixed method in anticipation that mixing methods will enable capture the complexity of human phenomena.

The researcher acknowledges the importance of positivism and constructivism approaches in mixed methodological approach to this research. Constructivism proposes that there are multiple realities and different interpretations that may result from any research endeavour (Appleton & King, 2002). Those interpretations are shaped by particular circumstances that exist as a study unfolds. Researchers who work within the constructivist paradigm seek to illuminate the reality of others through the process of detailed descriptions of their experiences (Appleton & King, 2002). In the interpretative paradigm, the researcher is subjective with the focus directed at deeper understanding of what is happening with a smaller sample. Understanding farmers' perception of climate variability and change involves constructivism approach as it acknowledges that social phenomena play a key role in the construction of individuals' perceptions of the world around them. Positivism contends that there is a single reality and therefore seeks to identify causal relationships through objective measurement and quantitative analysis (Firestone, 1987). In the positivist paradigm, the researcher is considered independent and objective using larger samples to test carefully constructed hypothesis. The prevailing wisdom is that the researcher in the positivist tradition can put aside values to avoid

¹ Research in which the investigator collects and analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches or methods in a single study.

bias in a process of inquiry. The positivist viewpoint is that the research outcomes are not biased by the values of the detached positivist researcher unlike in the constructivist paradigm where the researcher is immersed in the research (Firestone, 1987). The assumption is that logical positivism is objective, whereas the naturalistic inquiry is subjective. The simplistic view of quantitative research is that it is an objective process of deduction whereas the qualitative process is subjective and a process of induction that can only be viewed in context (Morgan, 2007). The researcher acknowledges the importance of positivist paradigm to understanding climate resilience in smallholder farming. The debates on quantitative versus qualitative approaches have resulted in an illusion that the two approaches are mutually exclusive. However, practice disciplines are sometimes overly concerned with ‘methodological acrobatics’ (Sandelowski, 2000:335). Despite these methodological acrobatics, some researchers believe that competition between paradigms is not helpful, and focus on ways in which traditional rivalries may be usefully combined (Sale *et al.*, 2002; Stevenson, 2004). As a result, the research methodology took a repetitive and flexible mixed methods approach.

3.3 Study location and respondents

3.3.1 Selection of study location and sites

Figure 3.1, shows districts where this study was conducted in Malawi namely, Chikwawa, Dedza, Nsanje and Zomba. Chikwawa District is located at 16°10' 0"S 34°45' 0"E (-16.1666700, 34.7500000), has a population of about 564,684 people, covers an area of about 4878 km² and has a population density of around 116 people/ km². Dedza district is located at 14° 15' 46"S 34° 11' 8"E (-14.2627300, 34.1855900), has a population of 830,512 people, covers an area of approximately 3754 km² and has the population density of 221 people/km². Nsanje District is located at 16° 45' 0"S 35°10' 0"E (-16.7500000, 35.1666700), has approximately a population of 299,168 people, an area of about 1,945 km² and a population density of around 154 people/km². Zomba is located at 15° 23' 0"S 35°20' 0"E and has a population of about 746,724, an area of 2363 km² and a population density of 316 people/km². The specific study sites in a particular study district are shown in Figures 3.2, 3.3, 3.4, and 3.5. These districts are located in lowland agro-ecological zone (Figure 3.6), though some parts of Zomba district fall in the mid-altitude agro-ecological zone. Selection of these districts was done purposively because historically except for Dedza which is a control district, they are frequently affected by climatic shocks, i.e., drought, dry spells, and floods among others (Hallegatte *et al.*, 2017). An illustration of how the study sites were selected is presented in

Figure 3.7. Malawi as a country is divided into three main regions namely northern, central and southern region. Of these, the southern region suffers severe land pressure due to increased migration from land-scarce areas in Mulanje and Thyolo into the upland catchment areas for cultivation and other human activities. This has really boosted the population resulting in small average land holding size of less than 0.5 hectares in most of the districts in the southern region including Chikwawa, Nsanje, and Zomba (Matchaya, 2008). This means that considering the average land holding size, agricultural production in the southern region is dominated by smallholder farmers. Among the popular crops grown by smallholder farm households in the study districts, include common beans which come second to maize as a food crop. Common bean is grown across the country in the agro-ecologies categorized according to altitude as high, medium and low. Many people both in rural and urban areas, especially those who cannot afford animal protein, depend on common bean as an important source of protein. Beans are high in calcium, magnesium, have large amounts of vitamin B, iron and zinc which are essential for immune function in humans. Again, in the major bean growing areas, 74 percent to 90 percent of farmers grow beans as their main cash crop (CIAT, 2013). Considering the fact that smallholder farmers are characterized by limited resource endowment, i.e., fertilizer, common bean as a legume crop may grow with little or no input of fertilizer because it has the capacity to fix atmospheric nitrogen into the soil. Hence, when grown in rotation with other crops such as maize or tobacco, beans improve soil fertility. When food shortages reach a climax, the common bean plays an important role in gap filling, as people depend on beans alone for their survival (CIAT, 2013). Despite this importance, common bean experiences high fluctuations in production associated with high variability in rainfall conditions, often resulting in excess market output demand. Considering the characteristics of the study sites and the selected crop, the researcher aimed to help build up a more comprehensive picture of smallholder farmers' resilience to climate variability and change in Malawi by focussing on the hazard/stress prone areas. The researcher has been questioned as to why they were interested to carry out resilience research in areas where there is constant attention by government to support farmers in times of climatic stress/shock in recent years. The researcher believed that understanding the smallholder farmers' resilience to climate change through perceptions approach and decisions on farming activities would explore the pathways to resilience in smallholder farming.

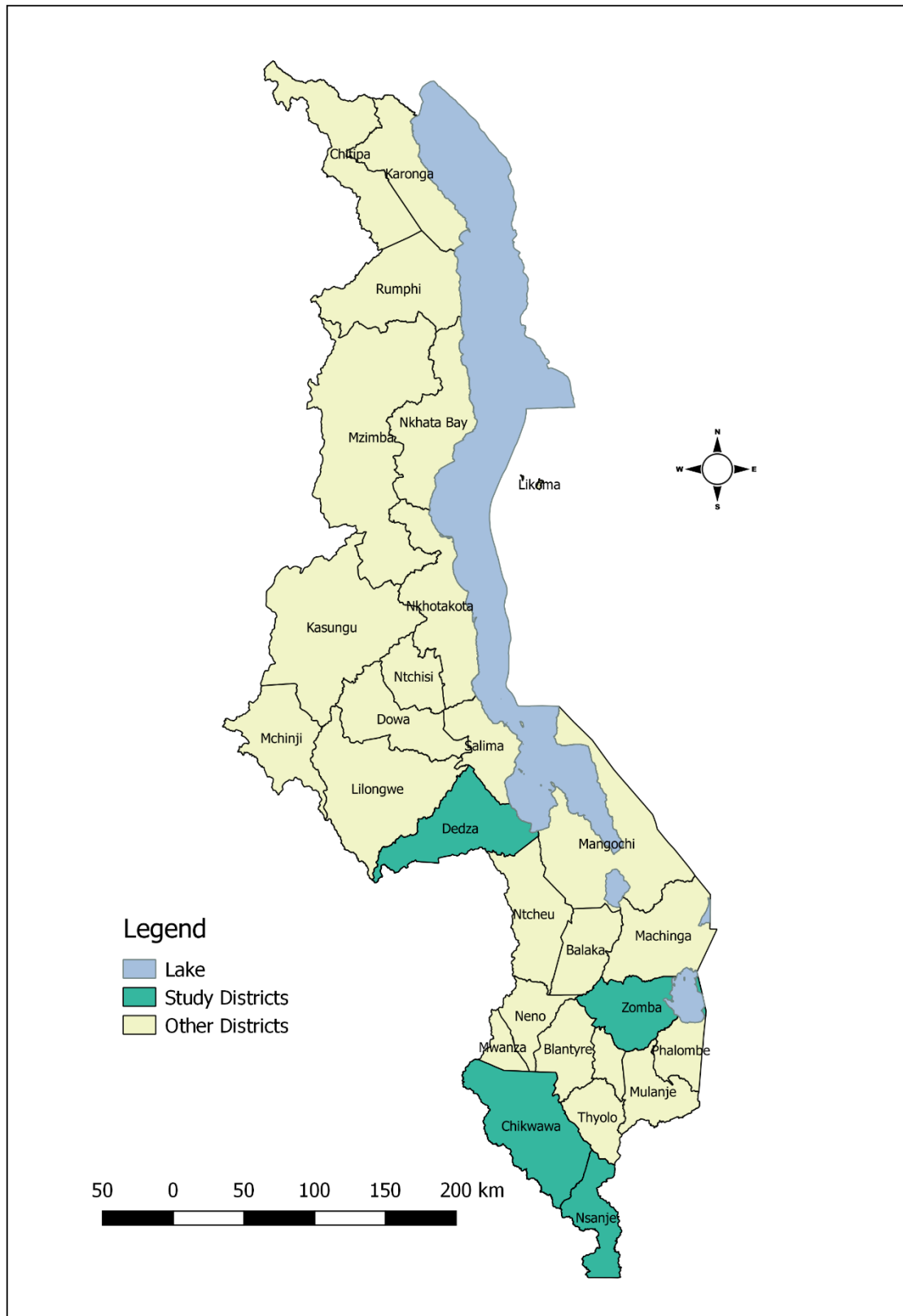


Figure 3. 1: Map of showing study district in Malawi

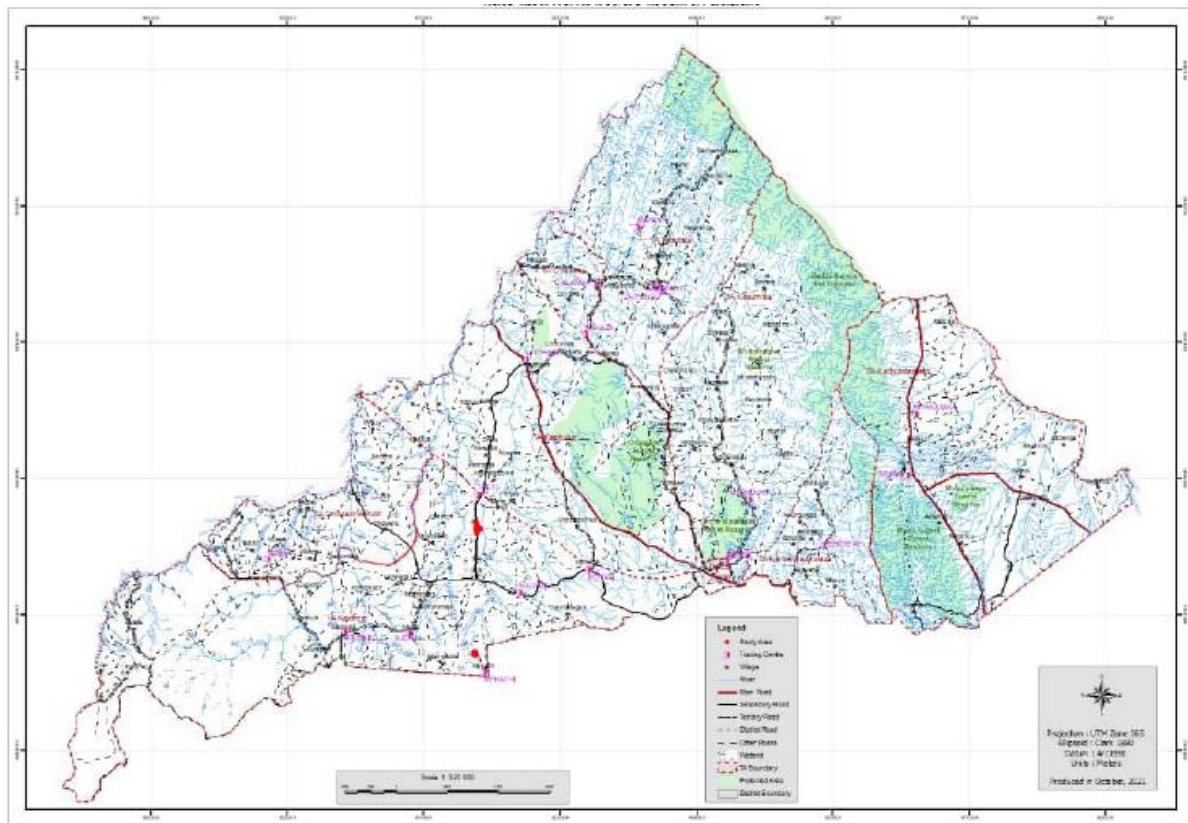


Figure 3. 2: Map showing study sites in Dedza district

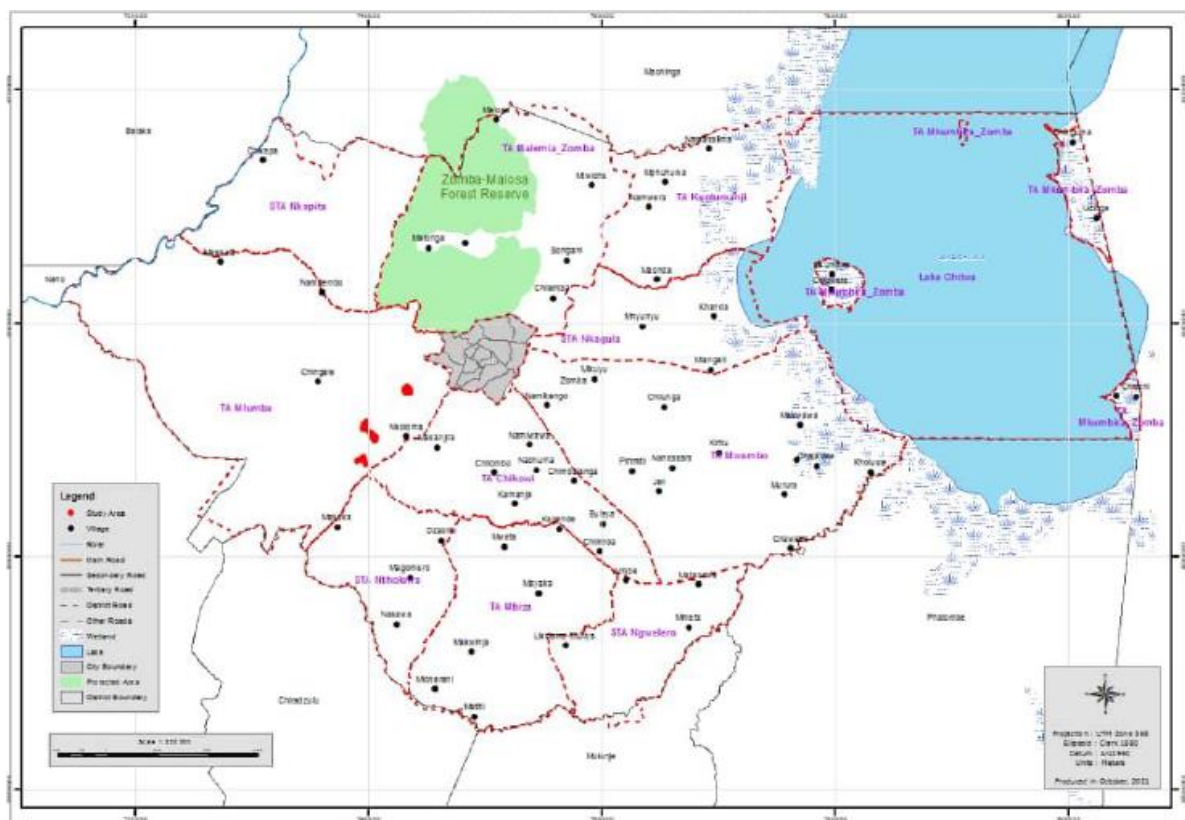
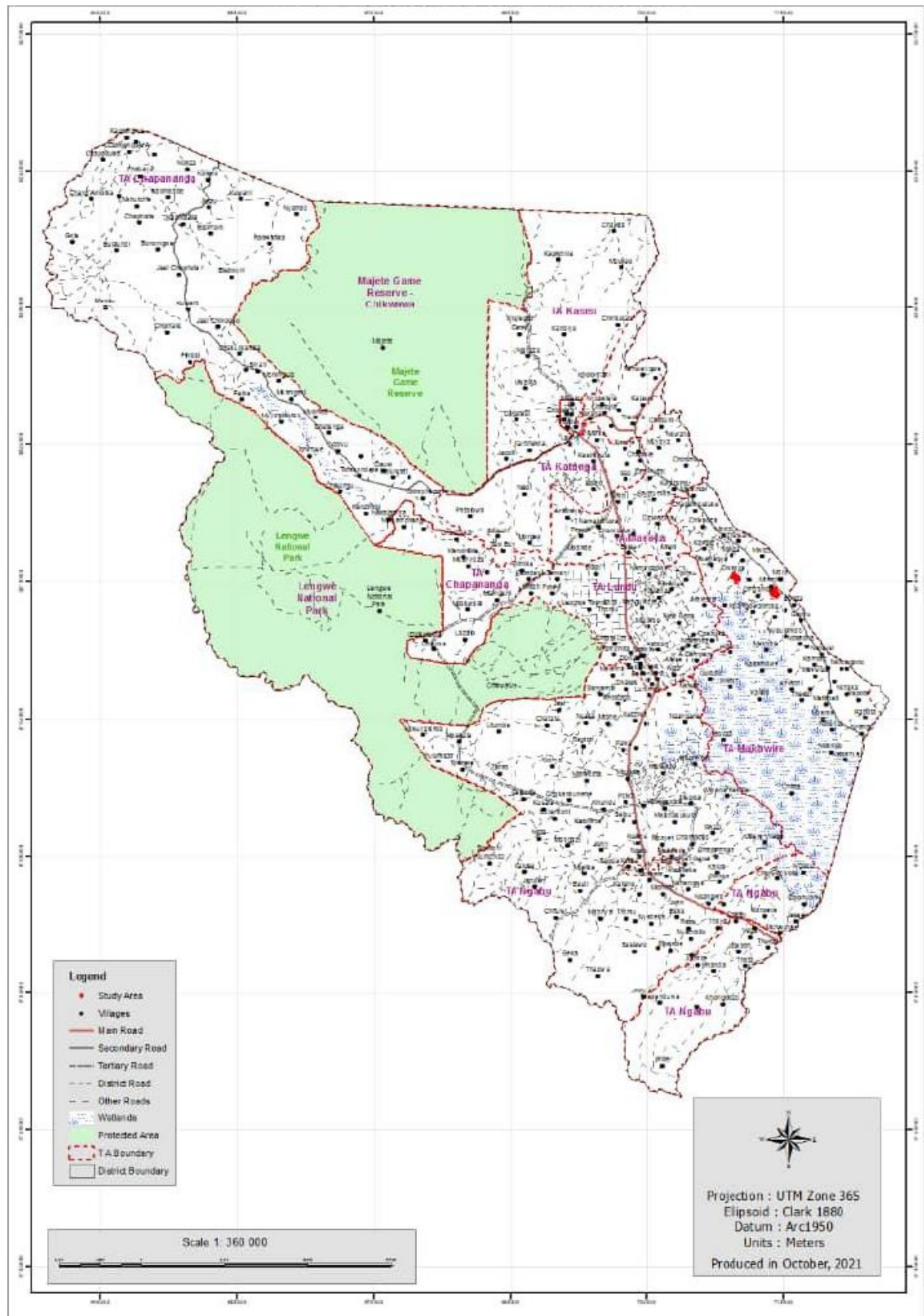


Figure 3. 3: Map showing study sites in Zomba district



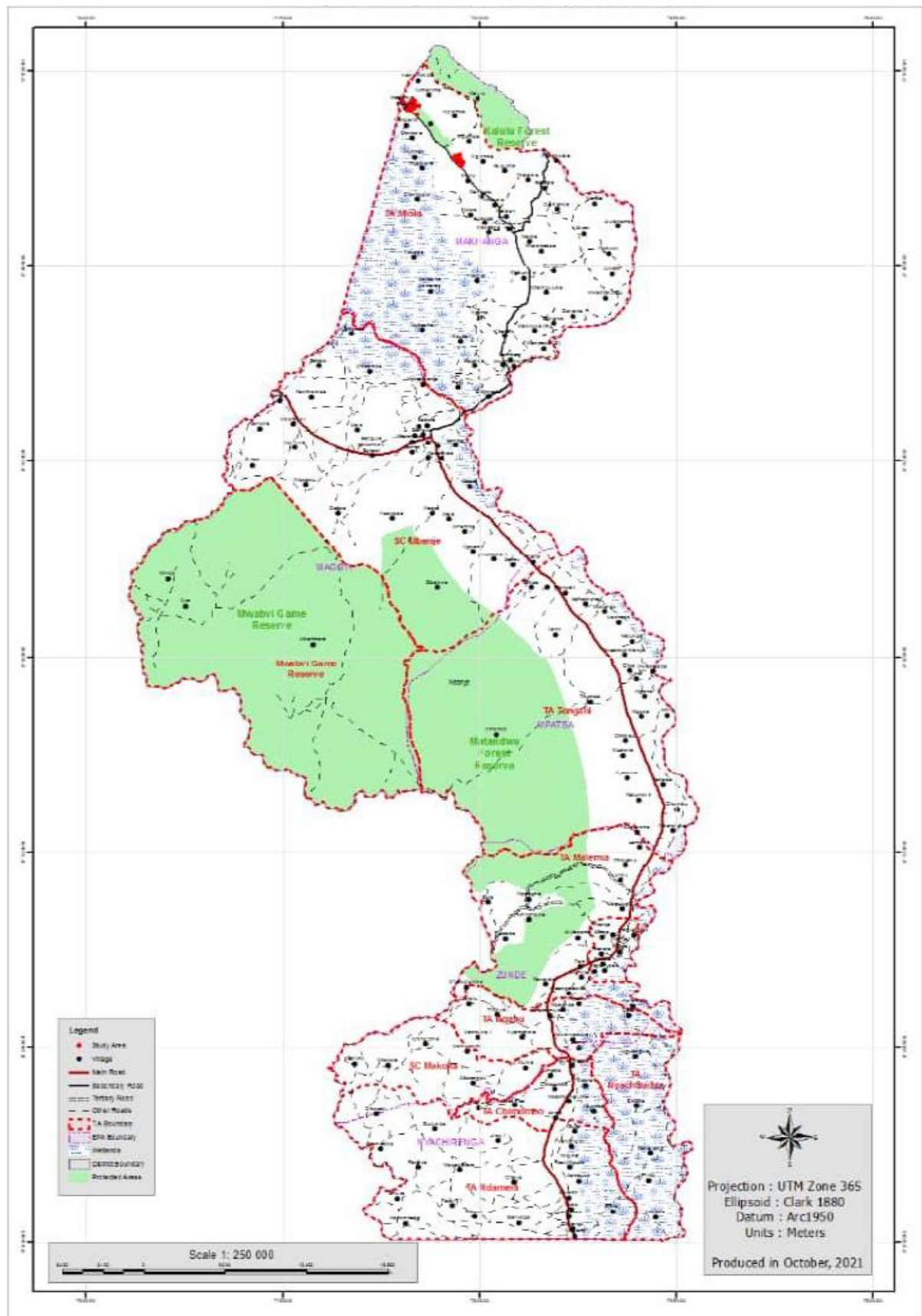


Figure 3. 5: Map showing study sites in Nsanje district

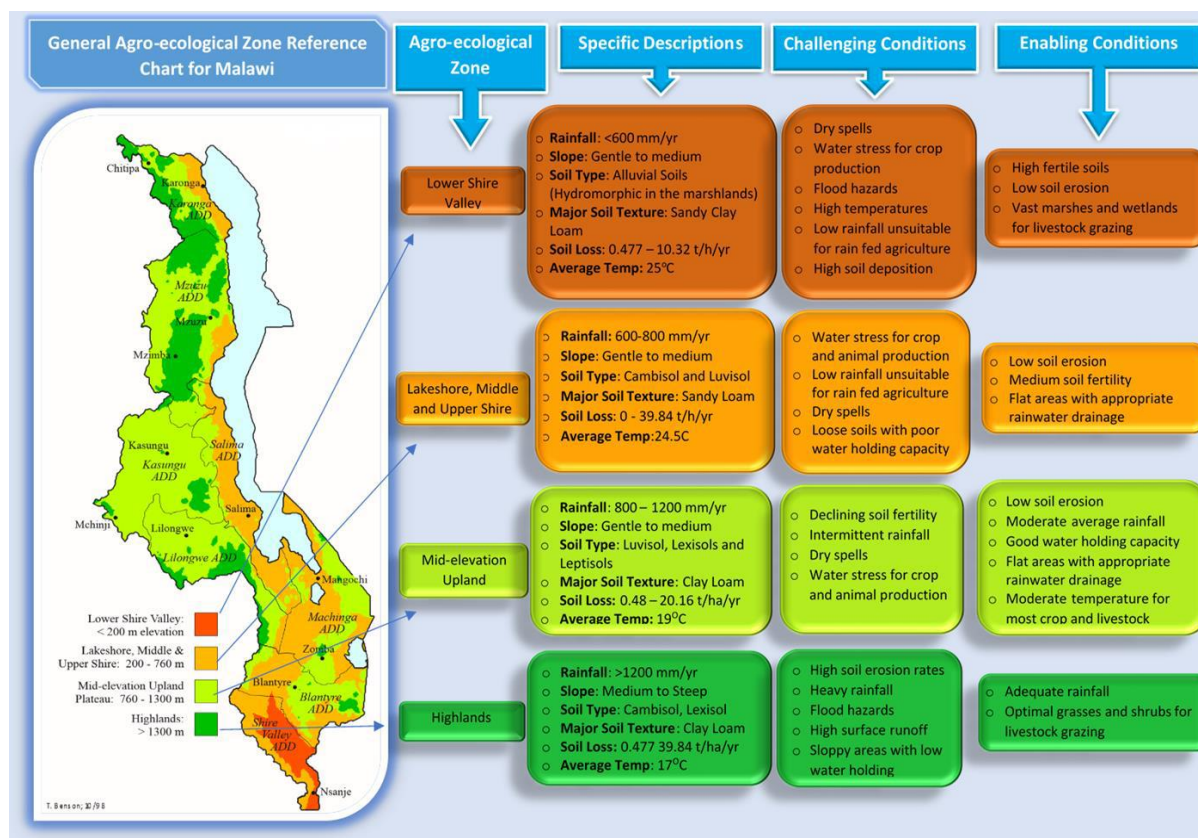


Figure 3. 6: General agro-ecological zone reference for Malawi

3.3.2 Selection of respondents

The study targeted a population of smallholder farm households (both male and female-headed) whose livelihood depend on agriculture, mainly those growing common bean as a crop of economic importance. The study subjects, therefore, were sampled using a multi-stage sampling. Firstly, for community participation approaches (focus group discussions (FGDs), trend analysis and pair-wise ranking), in each study district, one EPA was purposively sampled. From the sampled EPA, one section was sampled where three villages were selected. Finally, from the selected villages, participants were randomly recruited. The participants for the community participation approaches were categorized into three groups i.e., men groups, women groups, and mixed (men and women) groups. Each group comprised of ten participants with the mixed group having a 50:50 gender representation. This meant that each district had ten participant per approach per group making it 30 participants for the three groups and 90 participants per three approaches. As these approaches were conducted in four districts, the total number of participants for all the approaches across the study districts were 360 participants.

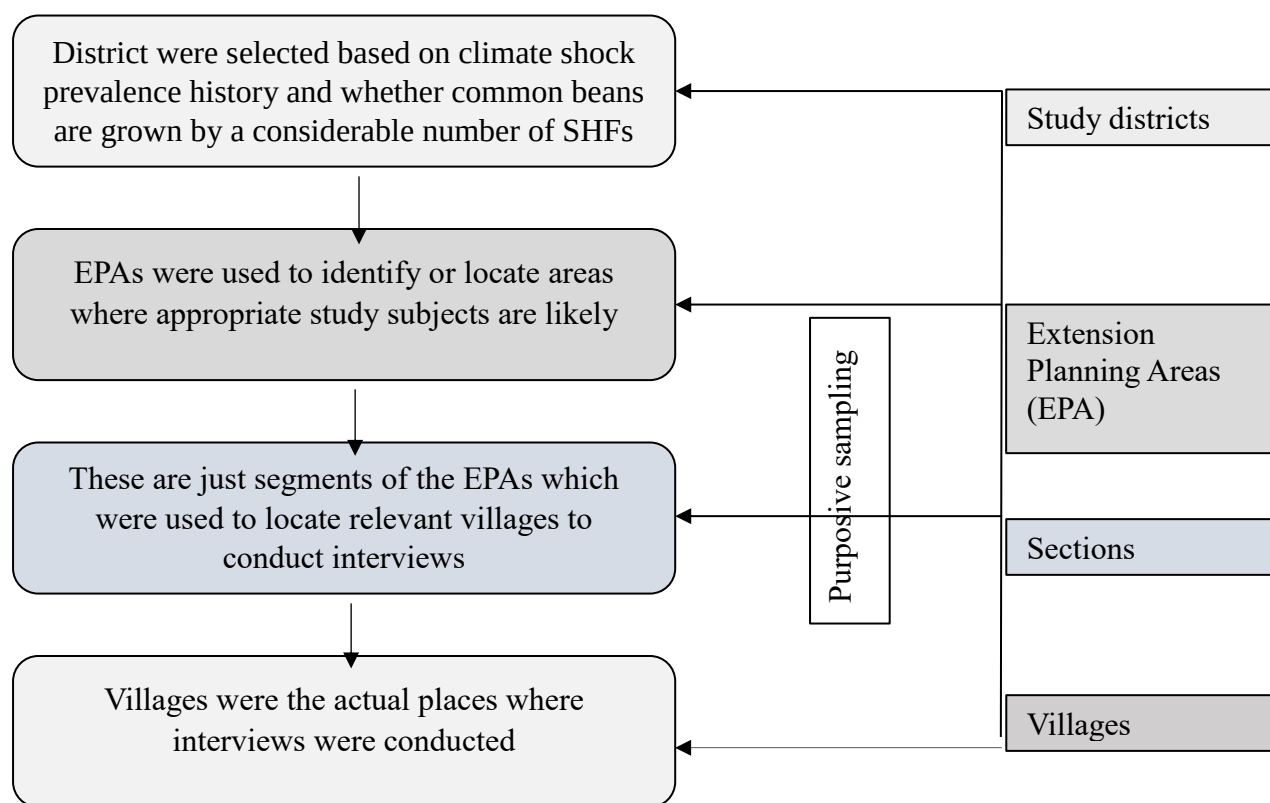


Figure 3. 7: Selection of study cites

These approaches helped to capture and explore relevant information, which was expected to be collected from suitable subjects that were directly or indirectly linked to the study sites, aware, and knowledgeable of the information required by the study. Secondly, a random sampling was done from the purposively sampled population, this was done to avoid biases in selecting the study participants. For a structured questionnaire, 356 respondents were randomly recruited from the same Districts, EPAs, sections and villages as in community participation approaches. A summary of the study population and sampling designs is presented in Table 3.1.

Table 3. 1: Summary of number of activities and participants against study methods and tool

Method	Specific tool	Group composition	Sampling technique	Number of EPAs per district	Number of sections per district	Number of villages per section	Number of farmers per village	Number of villages per district	Number of activities per district	Number of farmers per district	
Community participatory methods	Focus group discussions	Male	Purposive	1	1	1	10	1	1	10	
		Female	Purposive	1	1	1	10	1	1	10	
		Mixed	Purposive	1	1	1	10	1	1	10	
	Number of participants per district										30
	Trend analysis	Male	Purposive	1	1	1	10	1	1	10	
		Female	Purposive	1	1	1	10	1	1	10	
		Mixed	Purposive	1	1	1	10	1	1	10	
	Number of participants per district										30
	Pair-wise ranking	Male	Purposive	1	1	1	10	1	1	10	
		Female	Purposive	1	1	1	10	1	1	10	
		Mixed	Purposive	1	1	1	10	1	1	10	
	Number of participants per district										30
Questionnaire	Structured Questionnaire	Mixed	Random	-	-	-	-	-	-	356	
Total # of Districts				4	Total # of Participatory activities					36	
Total #of Sections per district				1	Total # of Trend analysis					12	
Total # of Villages per section				3	Total # of Pair-wise ranking					12	
Total # of Questionnaires				356	Total # of Focus Group Discussions					12	
Total # of farmers participated in community participation approaches				360	-						

3.3.3 Structure of selected methods

The data collection process of this study followed the scheme shown in Figure 3.8. Considering that Malawi's growing season normally starts end October to end April/early May, the research was scheduled to be conducted outside the farmers' busiest period of the season. However, due to unpredictability of the growing calendar, the anticipated busy period was not as busy as we expected. Hence, the research activities rolled out though at a slow pace. The study started with the community participation approaches (FGDs, trend analysis, and pair-wise ranking) followed by the structured questionnaire. The community participation tools were administered first in order to shape the construction and refine the questionnaire using the observations and experience gained

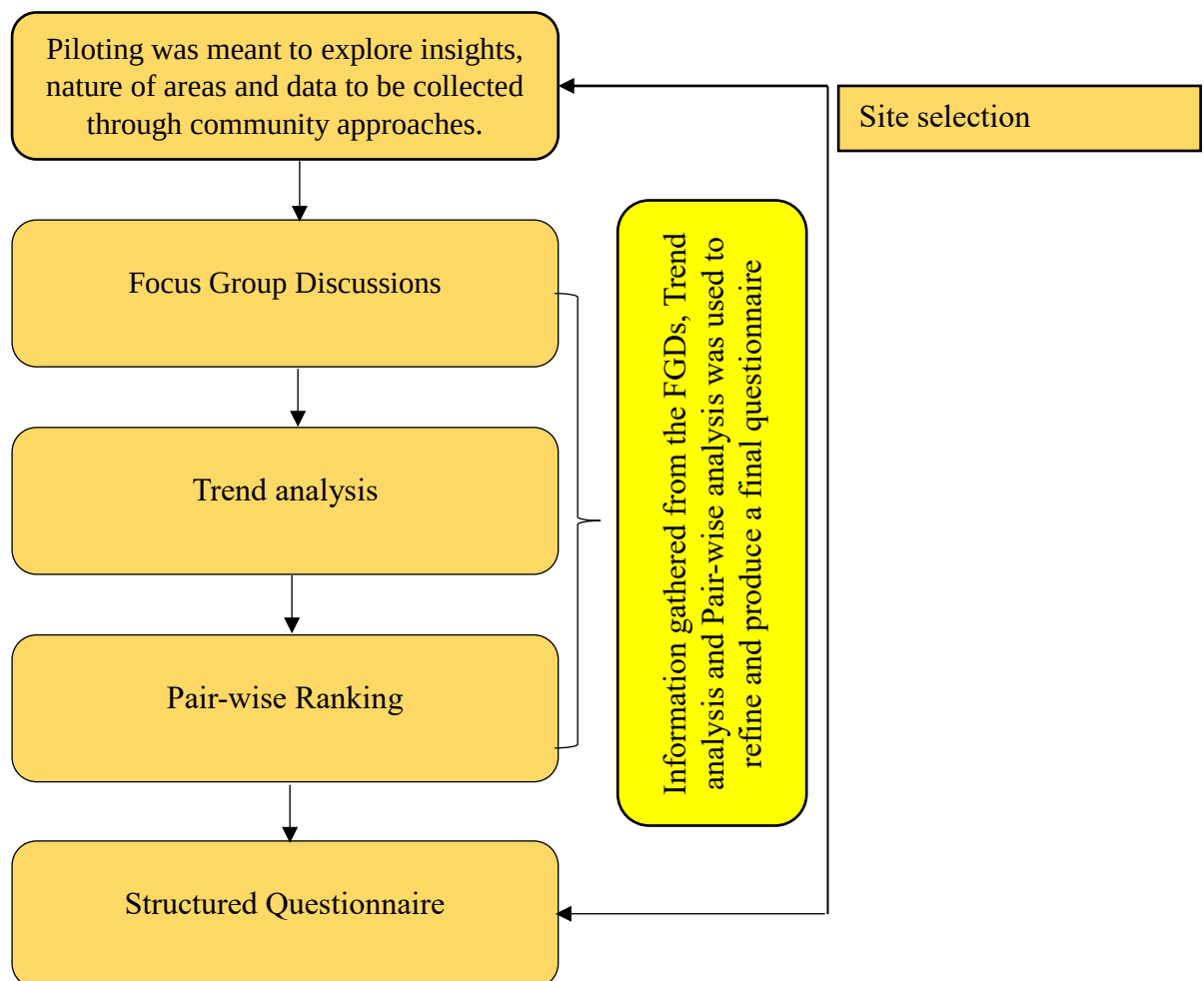


Figure 3. 8: Selected methods

3.3.4 Unit of analysis

As demonstrated by the researcher in the conceptual framework, the unit of analysis preferred for the research was the smallholder farm household. Considering the gendered nature of the research it was necessary that the household, more especially head of the household be the focus of the study. Whilst other researchers believe that such unit of analysis overlooks and essentialises the idea that different members of the household may possess diverse perceptions of climate variability and change based on differing degrees of interaction with affect-based and analysis based factors, as a direct result of the rule-based factors and their associated norms and values that exist within their particular communities and societies (Horsfield, 2016), most perceptions research have tended to focus on the household as a unit of analysis, with heads of the households as principal informants of the research. In studying perceptions, participation in decision-making and direct involvement as a pathway to climate resilience in smallholder farming, heads of households are normally at the pole of most of activities.

3.4 Data collection: methods and tools

Choice of methods used for data collection are based on researcher's skills, assumptions and research practices, resource constraints and time (Gounder, 2012; Robson, 2002). A well designed research was used to offers flexibility for mixed methods in data collection and analysis. In addition, mixed methods allowed for complementarity of methods in undertaking the research (Mayoux, 2006), and ensured maximum data triangulation (Bryman, 2016). The quantitative method used in this research provided an objective reality that exists independent of human perception, whereas qualitative methods are used to help researcher's understanding of people and the social and cultural contexts within which they live. The researcher understands that complementarity of these different methodological approaches add greater value to the research. The researcher collected both primary, and secondary data from Department of Climate Change and Meteorological Services. Emerging findings in the process of the data collection contributed to the focusing of methods used later in the study.

3.4.1 Timescale of activities during fieldwork

The methodological approaches and tools used in this research to collect data over the 10 months of fieldwork were participatory groups and tools (FGDs, pair-wise ranking and trend analysis), a structured questionnaire and secondary data (meteorological data). The main focus of all the methods used was on smallholder farmers and integrated gendered perspective, to ensure differences between men and women are effectively captured. Figure 3.9 illustrates a timeline of activities in relation to fieldwork, from conceptual and methodological framing to data collection.

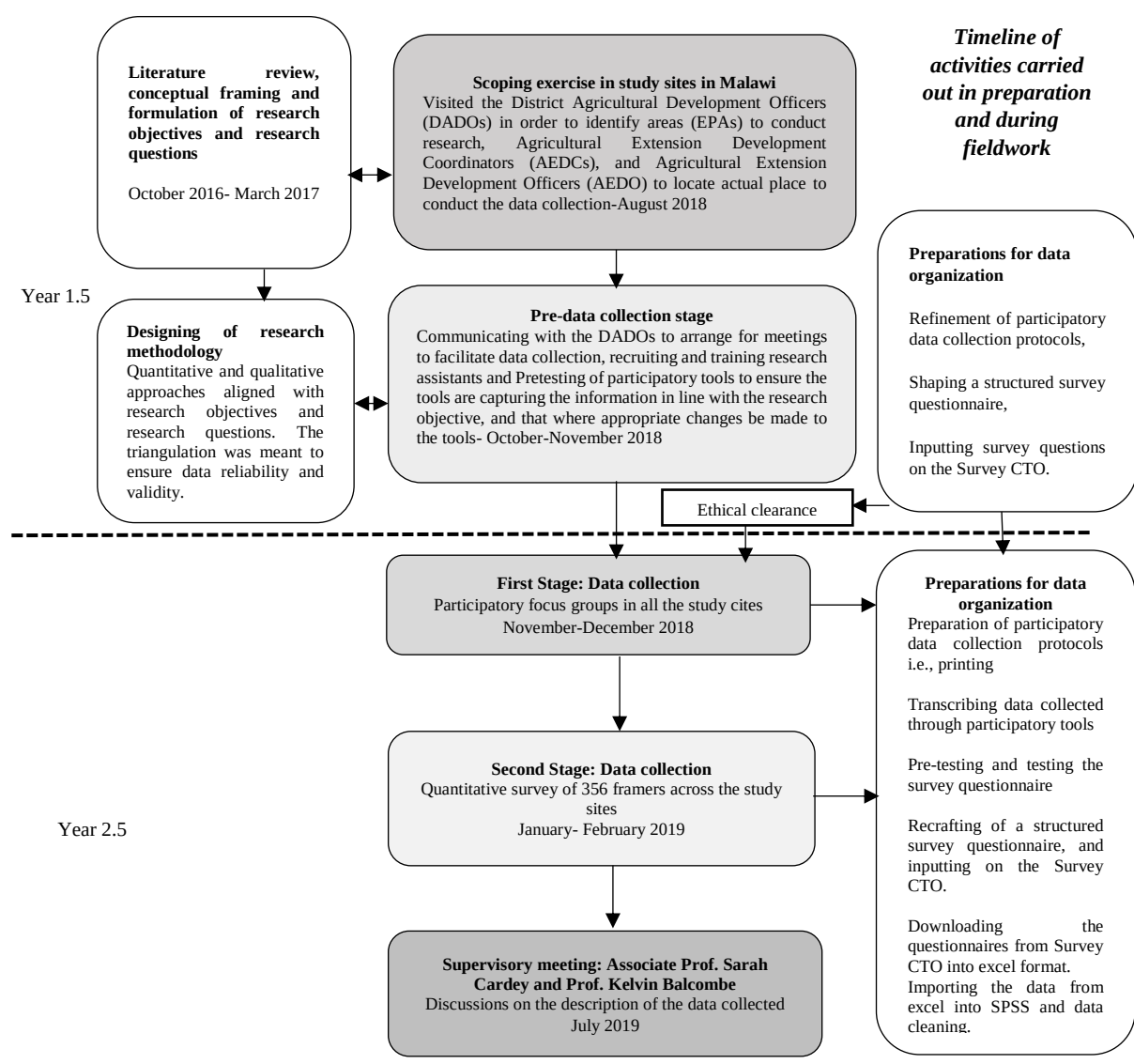


Figure 3. 9: Timeline of fieldwork activities

3.4.2 Scoping exercise in Malawi

The scoping visit to Malawi in August 2018 gave the researcher the chance to examine the conceptual framework in relation to the research problem and make adjustments based on the observations and emerging issues. During this time the researcher had an opportunity to briefly explain the intention of the scoping to DADOs, Crops officers, Environmental and Extension Officers. This visit was very important as it helped out to improve on other areas which were not clear in the data collection protocols/tools. This encounter provided insights needed to help shape the conceptual framing of the research problem, research questions, to some extent the specific objectives and sampling frames. The researcher also had an opportunity to explore the possibilities of getting hold of meteorological data for the study districts from districts' agriculture office. It was discussed that meteorological data at district level is only shared to other parties upon content from the department of climate change and meteorological services (DoCCMS). The researcher was advised to communicate to the Chief Meteorologist from the DoCCMS who was responsible for the data. This meteorological data was very important for the research to establish the basis for comparisons between perceived changes and actual changes based on meteorological records. Finally, the researcher has a clear map of what was expected in field.

3.4.3 Pre-data collection stage

During this stage of fieldwork, between October and November 2018, the researcher spent time refining the tools based on the insights captured during the scoping exercise especially for the participatory tools. Upon refinement of the tools at this stage, the researcher started making logistical arrangements, and recruitment of research assistants in preparation for the testing of the tools. This was necessitated in order that the researcher identified the areas that needed improvement in the tools. The recruited research assistants were training on how to administer the participatory tools. Before going for a testing of the tools, the research assistants conducted a pre-testing through role-plays amongst themselves. Interesting issues came through which attracted an improvement of the tools at that stage. Both pre-testing and testing of the participatory tools was done to ensure the research assistants have fully confidence and that there is uniformity in terms of how the data was expected to be collected. This testing exercise also helps to ensure that time management including expected time allocation per participatory group is observed. This is very important in planning the whole exercise and has implications to the utilization of the activity budget of the research. The researcher also took an opportunity

to refine the structured survey questionnaire and inputting it in the survey CTO on data collection tablets².

3.4.4 First stage of data collection: participatory groups

This study's first stage of data collection was committed to carrying out of participatory groups across the study sites. The following three tools were employed to explore the understanding of smallholder farmers of climate variability and change, indigenous knowledge of climate variability and change, decision-making of farm activities, resilience mechanisms or strategies they use in times of climatic shocks or stresses, and establish changes that have occurred over time as a result of varying and changing climate.

3.4.4.1 Focus group discussions

A focus group discussion is commonly defined as a method of collecting research data through moderated group discussion based on the participants' perceptions and experience of a topic decided by the researcher (Morgan, 1996). This approach was employed in order to understand farmers' practices, perceptions, and beliefs in the context of climate variability and change. Farmers were asked to explain their perceptions of climate variability and change, what indigenous knowledge or activities they possess and/or perform to challenge the changing climate. These discussions were recorded, transcribed and coded in Nvivo³. Thus, uncovering meanings and feelings, shared representations, specific topics that smallholder farmers experience. This approach is based on social interaction between the participants. The role of the researcher was to encourage and observe the discussions between individuals. In many cases, the focus group discussions are conducted in informal peer group settings. In this particular sense, focus groups are more of natural groups i.e. pre-existing social groups such as friends than artificial groups including people who do not necessarily know each other. The focus group discussions were organized into male, female and mixed groups. To avoid repetition in the proceeding participatory tools sections, the disaggregation of male and female groups was of gendered importance in order to understanding the manner in which men and women perceive climate related issues, in this case the impact of climate change in their farming systems. The guidance on focus group size is common and seldom goes beyond a

² An electronic gadget for collecting data.

³ Nvivo is a qualitative data analysis computer software package produced by QSR International.

minimum of 4 and a maximum of 12 participants per group. However, this study maintained 10 participants per group. At each research site, 1 FGD was conducted on each category of participants making a total of 12 FDGs from the four study sites per district. This was emphasized to ensure that quantity was balanced against quality as both too few and too many members per group have the potential to lower the quality of focus group studies.

3.4.4.2 Pair-wise ranking

The Pair-wise ranking is often used as a means of prioritizing or ranking and helps groups to arrive at their priorities and preferences and decide on which are the most important things to do. This approach was used to come up with a list of climate resilience mechanism/strategies that farmers normally employ in times of climatic shocks or stresses. The participating groups consist of male, female and mixed groups of approximately 10 individual participant per category and/or group. The mixed groups provided a space in which to explore the dynamics that exist between men and women in the group and their effects on farmer's identification of resilience mechanisms, the overall ranking of mechanisms to the varying and changing climate, and the importance ascribed to climatic resilience mechanisms. The pair-wise ranking exercise is based on the comparison of two items at a time such that decision on the importance of the item comes through the highest frequency. The more the frequency, the higher the preference for that item. But these frequencies come out through discussions and such discussions provide valuable insights into their decision-making process. These discussions were recorded, transcribed and coded in Nvivo. Basically, this approach is used in situations where a few items or options but not too many are expected to be compared, the core idea is to get people's priorities and preferences and getting an understanding of people's decision-making processes and probably their criteria for arriving at decisions.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	X	2	3	4	5	6	7	8	9	10	11	12	13	14
2	1	X	3	4	5	6	7	8	9	10	11	12	13	14
3	2	1	X	4	5	6	7	8	9	10	11	12	13	14
4	3	2	1	X	5	6	7	8	9	10	11	12	13	14
5	4	3	2	1	X	6	7	8	9	10	11	12	13	14
6	5	4	3	2	1	X	7	8	9	10	11	12	13	14
7	6	5	4	3	2	1	X	8	9	10	11	12	13	14
8	7	6	5	4	3	2	1	X	9	10	11	12	13	14
9	8	7	6	5	4	3	2	1	X	10	11	12	13	14
10	9	8	7	6	5	4	3	2	1	X	11	12	13	14
11	10	9	8	7	6	5	4	3	2	1	X	12	13	14
12	11	10	9	8	7	6	5	4	3	2	1	X	13	14
13	12	11	10	9	8	7	6	5	4	3	2	1	X	14
14	13	12	11	10	9	8	7	6	5	4	3	2	1	X

Picture 3. 1: A pair-wise ranking matrix from a women participatory group in Makhanga EPA, Gooke village in Nsanje study site
(Source: Fieldwork, December 2018)

RANKING	ID	DESCRIPTION
1	3&4	Mixed Cropping and drought resistant crops
2	2	Hybrid Crops
3	5	Planting gliricidia
4	1&6	Irrigation and minimum tillage
5	8	Checkdams
6	9	Manure making
7	7	Planting trees
8	10	Clubs
9	11	Village banks
10	12	Picksbags
11	13	Small businesses
12	14	Casual labor

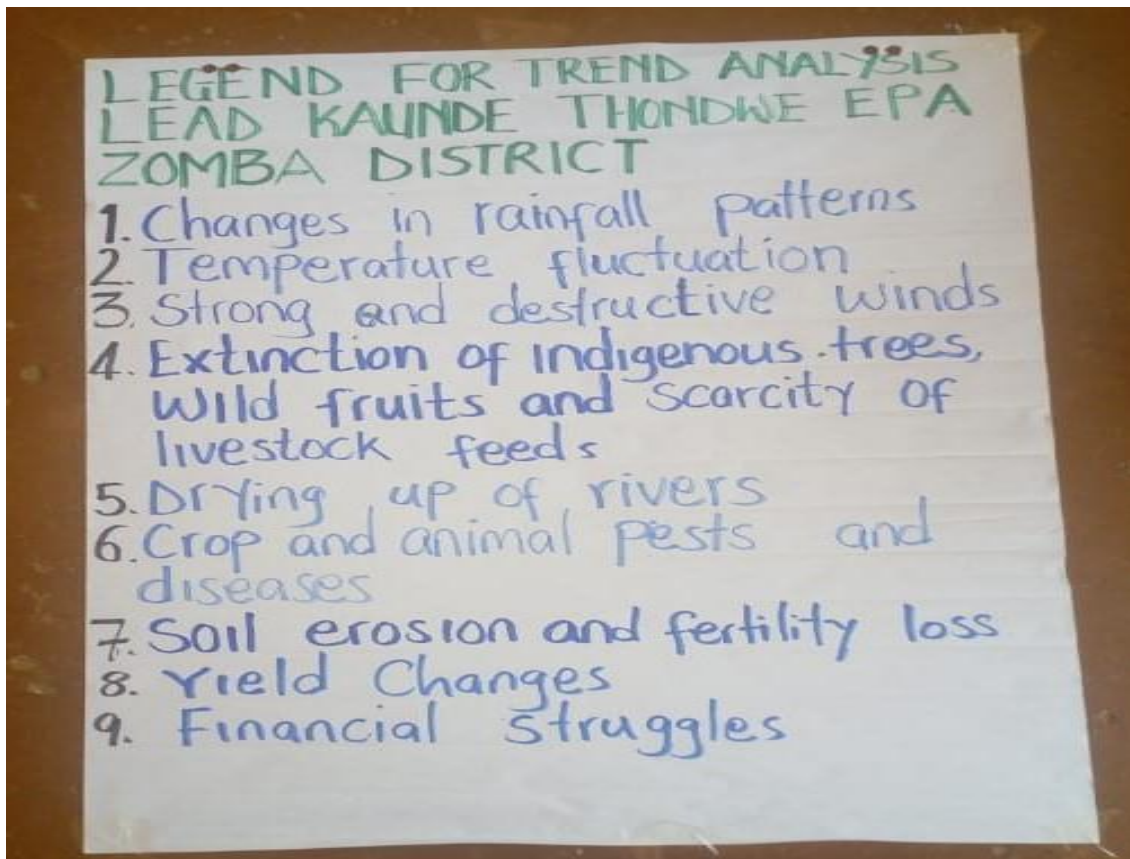
Picture 3. 2: Ranking climate resilience mechanisms based on pair-wise ranking matrix
(Source: Fieldwork, December 2018)

3.4.4.3 Trend analysis

Trend analysis was used in order to explore temporal dimensions with a focus to climate change. This approach was employed to capture farmers' experience over the changes and trends related to certain climatic variables over different spans of time. This approach is important because it recognizes that local people have a good understanding of the present situation and the changes that have taken place over the years. Generally, it helps to understand increases and decreases in the variables under study over a period of time. Trend analysis is useful in learning how the community perceives changes over time in various areas /aspects of their lives. Furthermore, help to understand people's perception of not only the past and present but also of the shape of things to come in the near or distant future with or without intervention (Kumar, 2002 p.128).

IZINDIKIRO	TSOPANO	5-10	10-15
1	-Alibe nthawi -Ingowaza	-Zidasintha -Chifukwa cha Chilala	-Abwino -Osadukiza -okhazikika
2	-MPhuma ingokhala nthawi iliyonse	-Pakatinoti	-Kudalindi mryezi -ake
3	-Yamphavu -Yothawitsa mvula -Yasakhazikika	-Imathawitsa mvula	-Kokhazikika -Kunalibe mphepo -Yopisa
4	-Kusasola zinthu -Nsipu udatha -Nyama ndi mitengo Kulibiletu	-Mitengo -Yochepa	-Imalozela nyengo -Mvula -Chilengedwe -Chidaliho -Nsipu wambiri -Nyama zamthengo -Zidatha
5	-Idauma	-Idayamba kuchepa	-Idali Yambiri
6	-Mankhwala ena sakhugwira nitchito -Matenda achulukwa -Anthu akudwaladwala -Zakudya zikuchulukwa mankhwala	-Amachizika komaso sanali ochulukwa	-Matenda amachizika mnsanga -Zifatala -Zimadalilika
7	-Kulibe chonde -Kudalira fetereza	-Kusasamala Polima ngati akalozesa Kupangitsa nthaka Kukokoloka	-Chonde Chambiri Kulima opanda fetereza
8	-Kukolola zamimanga	-Moderate harvest	-Zokolola zamimanga Chifukwa cha nthaka Yakhazikika -Mvula inaliko Yakwana
9	-Ndalama zikusowa -Sizilibwino	-Moderate Income	-Ndalama zokwanira Chifukwa zokulitsa Zinalipo Chuma chokhazikika Chifukwa zifaliso ndi zosinthira Zidalipo

Picture 3. 3: Trend analysis of a mixed participatory group in Thondwe EPA, Lidi Kaunde Section, Mtalimanja village, Zomba study site
(Source: Fieldwork, November 2018)



Picture 3. 4: Legend for climate related events based on trend analysis of a mixed participatory group in Thondwe EPA, Lead Kaunde Section, Mtalimanja village, Zomba study site

(Source: Fieldwork, November 2018)

The approach was conducted with male, female and mixed groups in order to capture to how men and women perceive the changes and trends of climate variables and their related impacts to crop production system. These discussions were recorded, transcribed and coded in NVIVO. The groups consist of 10 participants each across the study sites. Mixed groups provided an environment of multiples views coming from two different genders that are presumed to have different roles and experiences in agricultural production. Such differences contributes to divergence of perceptions of climate related issues between the genders and provide a good platform for modification of behavior and perceptions of trends to group norms conformism/entativity).

3.4.5 Second stage of data collection: structured questionnaires

After using community participation approaches, a series of questions (or other types of prompts) was developed in form of questionnaire for purposes of gathering information from respondents. This approach has some advantages over other surveys in that they often have standardized answers that make it simple to compile data. A questionnaire for this study was used to collect data from 356 smallholder farm households across the research sites. The questionnaire was used to collect the following data from the farm households; demographic/socio-economic characteristics, farmers perceptions of climate variability and change, climate shocks and crop production, coping and adaptation strategies, sources of climate variability and change information, decision-making on production and choice of adaptation strategies, and indicators of resilience components. The questionnaire was designed based on specific information areas, research objectives, research questions and conceptual framework.

3.5 Data analysis

This research employed a mixed approach to data analysis as dictated by the type of data collected. Hence, qualitative and quantitative approaches to data analysis was executed. In order to achieve this, the researcher developed a clear statistical analysis plan for quantitative data, and clear themes in the organization and analysis of the qualitative data prior to data collection. Upon completion of data collection process, the data was arranged based on research objectives, research questions around relevant information areas to allow for validity and reliability of the analysis. This was important as emphasized by [Yi \(2003\)](#), that before data analysis is conducted, clarification of what and why to analyse is key.

3.5.1 Qualitative data

This type of data was collected using the participatory approaches such as FGDs, pair-wise ranking, and trend analysis. Where appropriate photographs were captured, and the data collected was later transcribed using the developed templates and recordings of the sessions. The transcribed data was coded and categorized using Nvivo for narrative analysis and interpretations, comparisons and arguments around the research thematic areas. It should be mentioned here that qualitative data was basically used to complement the quantitative data to strengthen the emerging issues.

3.5.2 Quantitative data

This type of data was collected using a structured questionnaire. The data collection template for the questionnaire was designed in MS Excel and then loaded on survey CTO⁴. After completing the data collection process, the data was imported from the survey CTO back into MS Excel and from Excel to SPSS. The preliminary analyses were done in SPSS to explore the behaviour of the data through descriptive statistics as a data cleaning process. After establishing the behaviour of the data, inferential statistics was conducted using binary, ordinal logistic, and general linear regression models in Gretl⁵. These models were chosen based on the nature and the behaviour of the variables of the data collected, research objectives and research questions. Where data was complicated especially in resilience variables which comprised of a large set of variables was reduced to a small data set while maintaining the most important information in the data set through the use of principal component analysis (PCA). The first principal factor from the PCA results was used to run the regressions in general linear models (GLMs). The data around resilience information and thematic areas was standardized and weighted for the GLMs. A summary of information areas, models and specific objectives and research questions covered are presented in Table 3.2.

Table 3. 2: Summary of models based on information areas, objectives and research questions

<i>Models used</i>	<i>Information areas</i>	<i>Specific objectives and research questions covered</i>
Binary Logistic Regression	Farmers' demographics, and socio- economic characteristics, Farmers perceptions, knowledge and impacts of climate change, decision- making in participation and involvement in farming activities, and on use of adaptation strategies	Objectives 1&2 Research questions 1.1, 1.3, 2.1 & 2.2
Ordinal Logistic Regression	Farmers demographics, and socio-economic characteristics, farmers perceptions of climate change, attributes of subjective resilience	Objectives 1&3 Research questions 1.1, 1.4 & 3.2
General Linear Model	Farmers' demographics, and socio- economic characteristics, components of climate resilience	Objective 3 Research question 3.1

⁴ Data collection software

⁵ Analysis procedures and statistical package are highlighted in detail in each result chapter

3.5.3 Meteorological data comparing with farmer perceptions

Climate data on temperature and rainfall was provided by Department of Climate Change and Meteorological Services of Malawi. This data was in a form of daily records for a period running from the year 2007 to 2019. The data was processed to compute the monthly rainfall and temperature readings, and further annual rainfall and temperature was calculated using some simple formulae for climate data computation. The mean monthly temperature (MMT) was computed by summation of daily mean temperature of a particular month divided by number of days in a particular month. Whilst the annual mean rainfall was computed by summation of monthly rainfall readings, divided by the number of years in the data. This data was important to help establish the relationship that exist between the farmers perceptions of rainfall and temperature with statistical trends over time. This data also helped to reveal whether or not the farmers' perception of climate variability and change are consistent with climate data. The trends of rainfall and temperature were generated in MS excel.

3.6 The researcher's perspective, positionality and reflexivity

Though mostly adopted in qualitative research, perspective, positionality and reflexivity are relevant even in quantitative research particularly in understanding and carrying out of critical research. Perspective refers to a particular attitude towards or a way of regarding something; a view point. [Clarke & Davison \(2020\)](#), defined researcher perspective as a particular stakeholder perspective that is adopted by a researcher as the, or a, viewpoint from which to observe phenomena during the conduct of a research project. The notion "research perspective" is quite distinct from the "object of study"⁶ and the "unit of study"⁷ that are adopted in a research project. Researcher perspective, on the other hand, refers to the direction or orientation from which the observations of the phenomena are undertaken. The perspective that the researcher adopts has a very significant influence on the entire research undertaking, commencing with the conception of the research, and moving on through the selection and formulation of research questions, to the research design. The choice that the researcher makes effectively determines what is included among and excluded from the potential outcomes of the research, how those outcomes are expressed, and the contributions that the research can make. Reflexivity involves researchers, thinking deeply or carefully about the way research is

⁶ The set of phenomena that the researcher observes

⁷ The level of granularity at which observation is conducted

carried out and understanding how the process of doing shapes its outcomes (Hardy *et al.*, 2001). According to Mavin & Corlett (2018), reflexivity is always a self-monitoring of, and self-responding to, our thoughts, feelings and actions as we engage in research projects. Linstead (1994), conceded that lack of reflexivity from a positivistic point of view has been associated with existence of bias on the part of the researcher, and that bias is assumed to distort the “true” picture should, therefore, be eliminated. Positionality “reflects the position that the researcher has chosen to adopt within a given research study”. Positionality is normally identified by locating the researcher about three areas: (1) the subject under investigation, (2) the research participants, and (3) the research context and process (Malterud, 2001). It influences both how research is conducted, its outcomes, and results (Rowe, 2014). It also influences what a researcher has chosen to investigate in *prima instantiapertractis* (ibid). Positionality allows, acknowledges and locates the researcher’s views, values, and beliefs about the research designs, conduct and output (Holmes, 2020). Reflexivity informs positionality. It requires an explicit self-consciousness and self-assessment by the researcher about their views and positions and how these might, may, or have, directly or indirectly influenced the design, execution, and interpretation of the research data findings (Greenbank, 2003; May & Perry, 2017). Reflexivity necessarily requires sensitivity by the researcher to their cultural, political, and social context Bryman (2016), because the individual’s ethics, personal integrity, and social values, as well as their competency, influence the research process (Bourke, 2014; Greenbank, 2003). It is essential for new researchers to acknowledge that their positionality is unique to them and that it can impact all aspects and stages of the research process. As Foote & Bartell, (2011p.46) identify

The positionality that researchers bring to their work, and the personal experiences through which positionality is shaped, may influence what researchers may bring to research encounters, their choice of processes, and their interpretation of outcomes.

Positionality, therefore, can be seen to affect the totality of the research process. It acknowledges and recognizes that researchers are part of the social world they are researching and that this world has already been interpreted by existing social actors. This is the opposite of a positivistic conception of objective reality. Positionality implies that the social-historical-political location of a researcher influences their orientations, i.e., that they are not separate from the social processes they study. Simply stated, there is no way we can escape the social

world we live in to study it ([Hammersley & Atkinson, 1995](#); [Malterud, 2001](#)). The use of a reflexive approach to inform positionality is a rejection of the idea that social research is separate from wider society and the individual researcher's biography. As such the researcher wished to make clear their positionality in the context of Malawi's recent history in order to expose any potential bias in the research.

3.6.1 The researcher's perspective and positionality

The researcher is a Malawian bonafide, born and spent most of his life time in central region of Malawi. The landscape of central region is quite different from those of southern and northern regions of Malawi such that a good number of activities are different too. The central region of Malawi has been known to be the food basket of the country and where most of agricultural activities are done. This region is also known of producing tobacco which is the main forex earner of the country. Since independence, this region was characterized by people who were relatively richer compared to those from the two different regions. After a multi-party system of government was introduced in the country, the landscape of most of the things changed more especially in the central region. The political environment started becoming the one that formed divisions among people from the three regions. The distribution and allocation of resources was politically motivated. The researcher acknowledges that since the time in history, the study sites excluding Dedza, are known to be affected by extreme weather events such as floods, droughts and heat waves [Hallegatte et al., \(2017\)](#), which have left the population in an awkward situation. The researcher also acknowledges that the southern region is affected by prevalence of biotic stresses such as crop and animal pests and diseases. Considering that the researcher comes from the region where these are uncommon, it was unlikely that the researcher could have unbiased research process. Further, considering that at each and every time when Southern region is affected by extreme weather events, the Government, NGOs, and charity organizations normally come in for safety nets. The researcher acknowledges that due to this support by the Government and NGOs, people from these areas do not want to relocate to settleable places in order that they continue benefiting from support that usually come in such times. The researcher realized that collecting data on assets, income and food, and associated data, was going to be problematic as people from these areas always expect such kind of activities as inventory for assistance targeting. The researcher, having all this information at the back, opted to approach the study subjects with an open mind and made sure that the data collection tools had enough follow up questions/checklists to help sieve the

exaggerated information provided. However, it should be pointed out that this trap was not easy to avoid.

3.7 Limitations of the study

A pathway to smallholder farmers' climate resilience is complex as is illustrated in the researcher's conceptual framework. It encompasses farmers' perceptions, adapting the production systems to climate variability and change, and decision-making. The researcher understands that perceptions of climate variability and change are dynamic and that they change over time. Further, decision-making on production activities is affected by a multitude of exogenous factors. The researcher also acknowledges that resilience is a construct that is difficult to measure or assess considering the nature of variables. Finally, combination of subjective and objective approaches to the understanding of climate resilience offers a greatest challenge due to unavailability of comprehensive data.

3.8 Chapter summary

This chapter pursues the detailed epistemological approach to undertake this research, the researcher's perspective, positionality and reflexivity, and the methods and tools used to collect data. It further discusses comprehensively the site selection of study location and specific sites, and data analysis. Where appropriate, details of some result chapter methodological approaches have been discussed in detail. The following chapters (four to six) comprise empirical methods and research results presented in accordance with the three specific objectives of the study (refer to Section 1.3 of Chapter 1). The next chapter focuses on Objective 1 and describes farmers' perceptions, knowledge, and impacts of climate variability and change in smallholder farming.

CHAPTER 4. PERCEPTIONS, KNOWLEDGE AND IMPACTS OF CLIMATE VARIABILITY AND CHANGE IN SMALLHOLDER FARMING.

4.1 Introduction

This chapter seeks to address Objective 1 of the study, which discusses the empirical findings on farmers' perceptions, knowledge, and impacts of climate variability and change in smallholder farming. The remainder of the chapter is structured as follows. Section 4.2 presents the analytical framework and estimation techniques of farmers' perceptions of climate variability and change, followed by empirical specification of the model variables in Section 4.3. Definition of variables and summary statistics are in Section 4.4, presentation of results and discussions in Section 4.5. Section 4.6 concludes the chapter with a summary of the findings.

4.2 Analytical framework and estimation technique

4.2.1 Analytical framework

This analytical framework is built on the insights from conceptual framework which acknowledges that farmers' perceptions of climate variability and change influence on how actions/responses are made in smallholder farming. It further acknowledges the importance of gender inclusion in farming activities and decision-making to improve on the capacity to deal and react to the disturbances. The hypothetical model that guides the empirical analysis rests on the human perception model frameworks that use cognitive data analysis tasks which support decision-making processes ([Ogiela, 2017](#)). There are several perception models, but this study uses the model of information representation in the human brain, which implies that information received by the human brain is kept in a form of a specific illustration, i.e., mental images, words (representing a given language), memory traces, judgments, schemes, concepts and ideas, mental models, notions, and knowledge structures etc.. Execution of such kind of information is done after routine processing using the knowledge possessed by the individual. In addition, a cognitive informatics model, is based on the distinguishable and describable similarities in the structure of the natural human mind, and its corresponding artificial "mind." This model involves a mental processing of characteristics for humans, such as perception, memory, thinking, data analysis, interpretation, reasoning, and predicting.

Similarly, smallholder farmers use the models of information representation in the brain, and cognitive informatics in the way they perceive climate variability and change among others. Climate variability and change continues to pose threats to natural, or human systems such that action is crucial to address and minimise its negative impacts (Elum *et al.*, 2017). Smallholder farmers' decisions on climate variability and change are normally guided by how they perceive the changing climate and its associated risks, such that appropriate action heavily depends on their ability to identify changes already taking in their areas and institute strategies, i.e., coping, adaptation, and mitigation among others (Adger *et al.*, 2005; Kihupi *et al.*, 2015; Moyo *et al.*, 2012; Ubisi, 2015). Action to climate change usually follows an analysis of perception of climate change as this is what stimulates an individual or group to react, or not, to perceived changing climate. Experiential and/or indigenous knowledge of the climate, coupled with the given observed impacts of climate change, shape individuals' or group's perceptions (Elum *et al.*, 2017). Sub-Saharan Africa has been described as the most susceptible region to the impacts of global climate change because of its dependence on agriculture which is extremely sensitive to weather and climate variables such as temperature, precipitation, and light and extreme events and low capacity for adaptation (Kotir, 2010). Measurement of farmers' perception of such climate variables is captured as dummy variables in the model which assign a value of 1 for farmers who perceive climate change variable and a value of 0 for farmers who do not perceive climate change variable, or more values assigned depending on the intensity and nature of the variables. This indicates that the probability of an individual with a given set of attributes will fall in one choice (perceive) rather than the alternative (or not) but not all (Uddin *et al.*, 2017).

4.2.2 Estimation techniques

This section presents estimation techniques of binary and ordinal logistic models to understand farmers' perceptions, knowledge, and impacts of climate variability and change in smallholder farming.

4.2.2.1 Binary logit model

In this chapter, the logit model was employed, due to the fact that the dependent variable (DV) is categorical in nature. Binary logistic regression is a type of regression analysis where the dependent variable $\{y_i\}$ is a dummy variable (coded 0, 1), i.e., whether or not the farmers

perceived change in the rainfall and/or temperature (perceived changes =1, otherwise =0). The set of explanatory variables $\{x_i\}$ can be binary or continuous.

The binary logit model can be rationalised by positing that there is an unobserved continuous latent variable $\{y_i^*\}$ that determines whether the observed DVs $\{y_i\}$ are either 0 or 1 depending on whether the latent variable is positive or negative. If it is further assumed that the latent variable is linearly determined by a set of regressors, along with an error term that is a differenced Gumbel random variable, then a binary logit is implied.

More specifically, defining the probability that the i^{th} dependent value (y_i) is 1 as p_i , and x_i as column vector of explanatory variables, the functional form of logit model is specified as follows:

$$\log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta'x_i \dots\dots\dots (4.1)$$

Where β' is a row vector of coefficients ($\beta_1, \beta_2, \beta_3 \dots \beta_K$) and β_0 is an intercept term and $\log()$ represents the natural log.

From equation 4.1, it can be seen that the coefficients in the model represent the change in the “log odds” that the dependent variable is 1 given a unit change in the associated explanatory variable. However, marginal effects (MEs) can be calculated at a given value for the regressors. These reflect the expected change in p_i given changes in the regressors. In the case of the binary logit the change in the expected value of the observed dependent variable given changes in the regressors is an equivalent definition. Arguably, these are more easily interpreted than the log-odds, since they accord with the more common interpretation one would ascribe to the coefficients of a linear regression (for a linear model with linear terms only). Accordingly, these will be presented herein, and the discussions of the results, will be mainly in terms of the values of these marginal effects.

Formally, the marginal effect can be defined (at a given value for the regressors as) as

$$\frac{dE(y_i)}{dx_k} = \dots\dots\dots (4.2)$$

(where $E(.)$ is the expectations operator). However, the marginal effect can also be interpreted approximately in discrete terms as the change in the expected value of the observed dependent variable given a one unit change the regressors

$$\frac{dE(y_i)}{dx_k} \sim = \frac{\Delta E(y_i)}{\Delta x_k} = \frac{\Delta p_i}{\Delta x_k} \text{ for } \Delta x_k = 1 \dots \dots \dots (4.3)$$

(where $\sim$ denotes approximately equal). The binary logits, their marginal effects and their associated standard errors were calculated using the lp-mfx package in *Gretl* ([Gretl Team, 2021](#)) which supports the evaluation of marginal effects in three modes. Herein the marginal effects have been calculated at the means of the regressors.

4.2.2.2 Ordinal logistic regression model

Smallholder farmers' future anticipation of perceived climate variability and change, and production changes that have taken place over the past 10 years in common bean farming systems were estimated using an ordinal logistic regression model.

Ordinal logistic regressions assume that the observed dependent variable y_i takes a set of integer values, that are determined by an underlying latent (unobserved) variable y_i^* whereby y_i takes a given integer value if the latent variable y_i^* lies between two thresholds. More specifically it is assumed that

$$y_i^* = \beta_0 + \beta'x_i + e_i \dots \dots \dots (4.4)$$

where, as before, x_i is a column vector of explanatory variables, β' is a row vector of coefficients ($\beta_1, \beta_2, \beta_3 \dots \beta_K$) and β_0 is an intercept term and e_i is a random variable that is the difference between two Gumbel distributions.

For the response values that are ordered with levels $j=1, 2 \dots J$, under the ordinal logistic model (proportional odds model), the probability of response level j is the difference in the cumulative probabilities at level j and level $j-1$, and can be calculated as

$$p_{ij} = Prob(\alpha_j < y_i^* \leq \alpha_{j+1}) = F(\alpha_{j+1} - m_i) - F(\alpha_j - m_i) \dots \dots \dots (4.5)$$

where:

$$m_i = \beta_0 + \beta'x_i \dots \dots \dots (4.6)$$

and α_j is the j^{th} threshold and $F(x)$ is the logistic cumulative distribution function

$$F(x) = \frac{\exp(x)}{1+\exp(x)} \dots \dots \dots (4.7)$$

The marginal effect of the k^{th} predictor, x_k , on p_{ij} can be defined as derivatives or terms of the changes in probabilities for a unit change in the value of the regressors.

$$\frac{dp_{ij}}{dx_k} \sim = \frac{\Delta p_{ij}}{\Delta x_k} \text{ for } \Delta x_k = 1 \dots \dots \dots (4.8)$$

From which the change on the expectation of the observed data for a unit change in the regressor is also referred to as a ‘marginal effect’

$$\frac{\sum_j j dp_{ij}}{dx_k} \sim = \frac{\Delta E(y_i)}{\Delta x_k} \text{ for } \Delta x_k = 1 \dots \dots \dots (4.9)$$

The marginal effect in (4.9) again corresponds more directly with the interpretation of a coefficient derived from a linear regression and, therefore, will be the principal measure used subsequently. The ordinal logits and their marginal effects and their associated standard errors etc. were calculated using the lp-mfx package in *Gretl* ([Gretl Team, 2021](#)) which supports the evaluation of marginal effects in three modes. Herein the marginal effects have been calculated at the means of the regressors.

This study, therefore, has used ordinal logistic regressions to model future anticipation of farmers’ perceptions of the changing climate. This is employed since the perceived future anticipation of the changing climate has dependent variables with more than two outcomes which are ordered ([Greene, 2003](#)). Smallholder farmers’ future anticipation of the changing climate has more than two outcomes. These are perceived increases, decreases, no changes, and don’t knows of the future changes of climatic variables which include rainfall, and temperature.

4.3 Empirical specification of model variables

The dependent variables are farmers’ perceptions of climate variability and change as potential shifts in the long-run mean and extremes of temperature, precipitation and other meteorological variables in a given area ([Mamba, 2016](#); [Uddin et al., 2017](#)). The farmers’ perceptions of variability and the changing climate were captured using dichotomous response questions (“yes/no”) about whether or not they had experienced changes in the amount of the main rainfall seasons, onset of the main rainfall seasons, ending of the main rainfall seasons, and long-term changes in temperature over the past 10 years. Further explorations were made based on farmers’ initial responses about how the perceived climatic variables have changed over the past 10 years. Recent studies of farmers’ perceptions of climate variability and change have

used the following responses to establish how the climatic variables have changed or occurred over time; experienced decreases, increases, no change, and/or they did not know ([Gadédjissou, 2015](#); [Tessema *et al.*, 2013](#)). In the case of this study, responses to the onset and the ending of the main rainfall seasons included the following: begins early and begins late; and stops early and stops late, respectively. In addition, questions were included on future anticipation of changes in rainfall, temperature, and observed changes in common bean production over the past 10 years.

At the household level, perceptions of changing climatic circumstances are linked in complex interdependences of drivers of climate adaptation that relate to agricultural productivity, and the socio-ecological adaptation strategies that are employed ([Zizinga *et al.*, 2017](#)). Likewise, an analysis of farmers' perceptions of the changing climate, help understand how they adapt, as this is what motivates an individual or a group to want to respond, or not, to any perceived climatic change, which normally is designed by pragmatic and or indigenous knowledge of climate and also the observed impacts of climate change ([Elum *et al.*, 2017](#)).

Except for Dedza, the study districts Chikwawa, Nsanje and Zomba are among the natural disaster areas (floods, droughts) in Malawi. Studies conducted in Shire Valley which is one of the disaster-prone areas indicate that local communities perceive the changing climate and mostly use indigenous techniques to cope with disaster ([Malunga, 2011](#)). Hence, compared to non-disaster-prone areas, higher perceptions are expected to be recorded in disaster prone areas.

Studies on gender perspectives of climate change adaptation conducted in South Tongu and Zabzugu districts of the Volta and Northern regions of Ghana found higher adaptive capacity to climate variability and change in males than females. Again, the study found higher mean climate adaptations in both male heads and male household members than in both female heads and female household members ([Adzawla *et al.*, 2019](#)). On the contrary, females are occupied in more farm activities than males, and have better experience and information, therefore, rendering the female-headed households more likely to adapt to climate change ([Nhemachena & Hassan, 2007](#)).

More years of farming experience coupled with perceived changes relate to capability in assessing the available technologies and finally making decisions for adaptation (Gbetibouo, 2009b). This contrasts the findings of [Adesina & Baidu-Forson \(1995\)](#), who found that an increase in the age or years of experience tend to increase the risk-aversion in adoption of

adaptation measures and further asserts that there is no final consensus on how age affects adoption decisions.

Farm household head literacy level is expected to increase the probability of the uptake of adaptation options to climate change according to [Gadédjisso-tossou \(2015\)](#), who found education level significantly increased adoption of planting short duration varieties as an adaptation measure to the changing climate.

Land holding size or land ownership is usually used as an indicator for wealth just like livestock, income and assets. Land holding size is hypothesized to have a positive relation with adaptation to climate change. Previous studies found that farmers who have their own land are more likely to adopt adaptation measures to climate change, especially if the investment required is attached to the land ([Gbetibouo, 2009b](#); [Nhemachena & Hassan, 2007](#)). This is directly related to the quantity the household is expected to produce from the land owned as an increase in the acreage/ or hecterage *ceteris paribus* increases the production.

Climate change awareness has an impact on farmers' adoption of adaptation measures such as changing planting dates or planting long or short duration crop varieties ([Deressa et al., 2008](#)). This can directly be related to access to information through group membership where information about the changing climate can be shared. It is hypothesized that farmers' group membership have decreased the farmers' propensity to adopt adaptation measures ([Gadédjisso-tossou, 2015](#)).

4.4 Definition of variables and summary statistics

The empirical literature; suggested behavioural hypotheses; and availability of data guided the choice of independent variables. Explanatory variables have helped in the development of the hypotheses concerning their expected influence on farmers perceptions of and/or adaptations to the changing climate (Maddison, 2007; Tessema *et al.*, 2013). Description of and hypotheses around, or expected signs of explanatory variables used in this study are shown in Table 4.1

Table 4. 1: Variable description and hypothesis for the impact of the independent variables on dependent variables and summary statistics

Variable	Description	Mean	SD	Expected sign
<i>AGEHH</i>	Age of household head (continuous)	44.16	11.22	±
<i>LANHODSZ</i>	Total amount of land owned by the household (continuous)	2.05	1.76	±
<i>GPMEMB</i>	Household memberships to any other group (continuous)	1.78	1.31	+
<i>BFARMEXP</i>	Number of years a household has been growing bean (continuous)	12.96	9.94	±
<i>FARMSZ</i>	Number of household members (continuous)	5.93	2.19	±
<i>GENHH</i>	Gender of household head (dummy, 1=male, 0=female)	0.77	0.42	±
<i>LITEHH</i>	Whether or not the household head can read and write (dummy, 1= read & write, 0= cannot read and write)	0.68	0.49	+
<i>CCAWARE</i>	Household member is aware of climate variability and change (dummy,1= yes,0 = otherwise)	0.92	0.27	+
<i>STDYDIST</i>	Household is located in districts (dummy,1= Dedza, 2 = Chikwawa, 3 = Nsanje, 4= Zomba)	-	-	±

Summary statistics of farm households in Table 4.1, indicate household head mean age of 44.16 across the study districts. This further indicates that farm households in the study districts are dominated by household heads within the working age population bracket which is defined as those aged between 15 to 64 (OECD, 2020). The average household size for Chikwawa, Dedza, Nsanje, and Zomba is 5.93 which is slightly higher than the national average household size of 4.5. This could be because out of the four districts where the study was conducted, three are from the southern region whose districts are known to have higher populations than districts

from the central and northern regions. In all the study districts, average farm households' land size is about 2.05 acres (0.82ha), which is below the national average land holding size of 1.2 hectares in Malawi. Land holding sizes have been declining since the 1970s, partly due to population growth of 3 percent per annum thereby exerting pressure on land due to massive conversion to new land uses i.e., agricultural production activities, settlements, and other profitable land use leading to reduced sizes of land allocation (NIP, 2015; Putri *et al.*, 2019). Farm households across the study districts have an average of 12.96 years of experience in common bean growing. Farming experience is largely useful as it helps farm households to adjust their farming practices through adopting improved technologies over time in response to disturbance or change (Ainembabazi & Mugisha, 2014). On average, farm households are members of two groups across the study districts. In terms of gender, results indicate 0.77 which means most farm households are male-headed. Regarding level of education, most of the farm households, fall in primary level or higher, evident by an average result of 0.68. This implies that most farm households can read information in the form of print media. Results indicate that most farm households are aware of climate variability and change evidenced by a mean of 0.92.

4.5 Empirical results and discussions

This section centres on presenting results and discussions on perceptions of the changing climate in smallholder farming. The perceived changes in climate include seasonal characteristics of rainfall, temperature, common bean production and other main crops, severity of climatic shocks and stress, effects on humans and livestock, gender perspective, and decision-making in the use of adaptation strategies to climate change. To avoid repetition when interpreting statistical tests, a 5 percent level of significance will be used in all tests unless otherwise stated (i.e., a statement that an effect is significant or that there is a rejection of the null will assume a 5 percent level of significance and conversely a statement that an effect is insignificant or is accepted will employ a 5 percent level of significance).

4.5.1 Smallholder farmers' perceptions of climate variability and change.

Climate variability and change variables are often perceived differently amongst smallholder farmers. Farmers observe several factors that indicate the changing climate, including rainfall and temperature. These climate variability and change observations are normally referenced to specific geographical regions such as the average state of the atmosphere for a given time scale (hour, day, month, season, year, decades and so forth), mostly attributed directly or indirectly

by human activities that alter the composition of the global atmosphere observed over a comparable time period (Houghton, 2002).

4.5.1.1 Seasonal characteristics of rainfall

4.5.1.1.1 Changes in the amount of the main rainfall season

Looking at the first row of Table 4.2, the majority of the respondents, 75 percent, perceive that rainfall has decreased during the main rainfall season over the past 10 years, and 24 percent perceive an increase. This indicates that the majority of respondents perceive changes in the amount of the main rainfall season over the past 10 years with a clear majority perceiving a decrease. A chi-square test shows a significant result on proportions of farmers' perceived decreases and increases in the main rainfall season. It is, therefore, reasonable to believe that a majority of farmers perceive that there are decreases in the amount of main rainfall season over the past 10 years. However, looking at the first row of Table 4.3, male and female respondents' perceptions of changes in the amount of main rainfall season are statistically insignificant.

Table 4. 2: Farmers perception on long-term changes and future anticipation of climate variability and change variables

Climate change issue	<i>n</i>	Decreased	Increased	Begin early	Begins late	Stops early	Stops late	No change	Don't know	Varies
Observed changes in main rainfall	355	268(75.3)	87(24.4)	-	-	-	-	-	-	-
Shifts in rainfall onset	356	-	-	164(46)	188(53)	-	-	-	-	-
Shifts in rainfall ending	352	-	-	-	-	278(78)	74(21)	-	-	-
Observed changes in temperature	352	47(13)	284(80)	-	-	-	-	-	-	-
Anticipated future changes in rainfall	356	209(59)	46(13)	-	-	-	-	14(4)	87(24)	-
Anticipated future changes in temperature	356	46(13)	209(59)	-	-	-	-	14(4)	87(24)	-
Production changes in past 10 years	356	258(72)	26(8)	-	-	-	-	12(4)	1(0.3)	59(16)

Note: Percentages in parenthesis

Table 4. 3: Farmers perception of climate variability and change disaggregated by gender

Climate		Female			Male			Chi ²
		Decreased	Increased	<i>n</i>	Decreased	Increased	<i>n</i>	
Observed changes in main rainfall		175(75)	59(25)	234	93(77)	28(23)	121	NS
Observed changes in temperature		53(23)	182(77)	235	19(16)	102(84)	121	NS
		Begins early	Begins late		Begins early	Begins late		
Shifts in rainfall onset		107(46)	125(54)	232	57(48)	63(53)	120	NS
		Stops early	Stops late		Stops early	Stops late		
Shifts in rainfall ending		186(80)	46(20)	232	92(77)	28(23)	120	NS
	Gender	Decreased	Increased	No change	Don't know	Varies	<i>n</i>	Chi ²
Anticipated future changes in rainfall	Female	130(55)	32(14)	8(3)	65(28)	0(0)	235	NS
	Male	79(65)	14(12)	6(5)	22(18)	0(0)	121	
Anticipated future changes in temperature	Female	130(55)	32(14)	8(3)	65(28)	0(0)	235	NS
	Male	79(65)	14(12)	6(5)	22(18)	0(0)	121	
Production change in the past 10 years	Female	174(74)	13(6)	9(4)	0(0)	39(17)	235	NS
	Male	84(69)	13(11)	3(3)	0(0)	20(17)	121	

Note: Percentages in parenthesis. NS (not significant)

4.5.1.1.2 Changes in the onset of the main rainfall season

Referring to the second row of Table 4.2, results indicate that 46 percent of respondents perceived the shift in rainfall onset as characterized by early, and 53 percent by late onsets. This difference is insignificant. However, despite this, the general perception about the shifts in onset of rainfall is statistically significant. It is, therefore, conceivable to believe that there are shifts in the onset of the main rainfall seasons over the past 10 years. Despite this, the third row of Table 4.3 indicates statistically insignificant results of male and female respondents' perceptions of changes in the onset of the main rainfall season.

Information of the onset of the main rainfall season is crucial as it helps the farmers to target planting/sowing times, thereby reduce chances of risking planting/sowing too early or too late. It also assists in timing farmland preparations, mobilisation of seeds/crops, manpower and equipment (Omotosho *et al.*, 2000).

4.5.1.1.3 Changes in the ending of the main rainfall season

With regards to the third row of Table 4.2, 78 percent of respondents perceived changes in the ending of the main rainfall season characterized by early stops, and 21 percent by late stops, and is significant. However, looking at the fourth row of Table 4.3, the results show statistically insignificant perceptions of male and female respondents on the ending of main rainfall season. Farmers' perceptions of ending of the main rainfall season have implications for the choice of the crop cultivars to use in their fields. If the rainfall season stops early in a particular location over time period, it is safer to use short duration cultivars in order to ensure they mature before the season ends. Similarly, if the rain season stops late, it is recommended that farmers use long duration cultivars to avoid post-harvest losses due to prolonged rainfall season (Sivakumar, 1988). Again, growth period has consistently had a positive effect on yields in many ecotypes (Ronghua *et al.*, 2019), hence, late stops of rainfall season may increase farmers' crop yields.

4.5.1.1.4 Anticipated future changes in rainfall

The fifth row of Table 4.2 indicates that 59 percent of the respondents perceived decreases, 13 percent increases, 24 percent not sure, and 4 percent no changes of future rainfall amounts. This difference is significant and suggests that a clear majority of the respondents anticipate decreases in the amount of future rainfall. However, the perception of anticipated future changes in rainfall disaggregated by respondents' gender (male and female) indicates statistically insignificant results (the fifth row of Table 4.3). Future anticipation can be used as an important opportunity to improve or establish futureproof (i.e., farmers' production management systems and helps to prepare for the future among others) in the presence of anticipated decreased amounts of future rainfall amounts (Pot, 2019).

4.5.1.2. Characteristics of temperature

4.5.1.2.1 Temperature changes over the past 10 years

In the fourth row of Table 4.2, farmers' observations of long-term changes in temperature show that 80 percent perceived an increase, 13 percent a decrease in temperature over the past 10 years, and 7 percent did not know. This suggests that a clear majority of respondents perceived increases in the temperature over the past 10 years. In terms of male and female respondents' perception of changes in temperature over the past 10 years, the second row of Table 4.3 show a statistically insignificant result. Farmers' knowledge of changes in temperature is important

in the production of crops including common beans (*Pharsalus vurguris*). Common bean is very sensitive to changes in temperature and has limited heat tolerance (Soltani *et al.*, 2019). Temperature higher than 30°C during the day or higher than 20°C at night are known to reduce seed yield in common bean. An understanding of temperature changes helps farmers to select the right cultivars to plant or sow depending on the level of cultivar tolerance to elevated, extreme low temperature or heat (ibid).

4.5.1.2.2 Anticipated future changes in temperature

Looking at row six of Table 4.2, approximately 56 percent of respondents anticipate increases in future temperature, 16 percent decrease, 5 percent no change and 23 percent had no idea about future temperature changes, again significant. This result suggests that the majority of respondents anticipate increases in the future temperature. However, with respect to the sixth row of Table 4.3, male and female respondents' perception of anticipated future changes in temperature show statistically insignificant result. Looking into the future and having an idea of how future events may unfold, helps better planning and coordination of actions to prepare for such events.

4.5.1.3 Perceived changes in common bean production and other main crops over the past 10 years in smallholder farming system

Results in seventh row of Table 4.2, show that farmers have observed changes in the production of common bean and other main crops over the past 10 years. A decrease in the production of common bean and other main crops was reported by 72 percent of respondents, with 16 percent reporting variations in production, 8 percent an increase, and finally 4 percent observed no change in production. This result suggests that the majority of respondents perceived a decrease in the production of common beans and other key crops over the past 10 years. From the male and female respondents' perspective, the results show statistically insignificant perception on the changes of common bean production and other main crops over the past 10 years (seventh row of Table 4.3). This information is important in establishing what is currently going wrong in the production system for improved or increased production.

4.5.1.4 Climatic shocks and stresses, and its perceived severity of on common bean production at farm household level.

4.5.1.4.1 *Climate shock/stresses*

[Figure 4.1](#) presents climatic shocks affecting common bean production and other crops. Farming activities are usually affected by several factors including those as a result of climate variability and change. Farm households were explicitly asked to take stock of the climate stresses or shocks that have been affecting their common bean and other main crop production over the past 10 years. Among several factors, droughts/dry spells were reported by 96 percent of respondents, 87 percent crop pests/diseases, 74 percent floods/too much rain, 65 percent heat wave, and finally 41 percent hailstorm. This suggests that drought or dry spells, floods or too much rain, crop pests and disease and heat wave are important climatic shocks and stresses affecting common bean and other key crop production. In terms of how these climatic shocks/stresses are perceived to affect male and female respondents, the results show statistically insignificant on the perception of drought/dry spells, floods/too much rain, and heat wave. However, male and female perceptions on crop pests/diseases, and hailstorm show statistically significant result (Table 4.4). This suggests that male respondents (93 percent) are highly affected by crop pests/diseases, while hailstorm highly affects female respondents (48 percent). The results imply that crop pest/diseases and hailstorm affect male and female respondents differently.

Environmental conditions are key to smallholder agricultural production which relies on, or are determined by, exogenous factors largely outside the control of farm families ([Sherlund et al., 2002](#)). The subsequent sub-section presents the severity of the climatic shocks and stresses on livelihoods and common bean production.

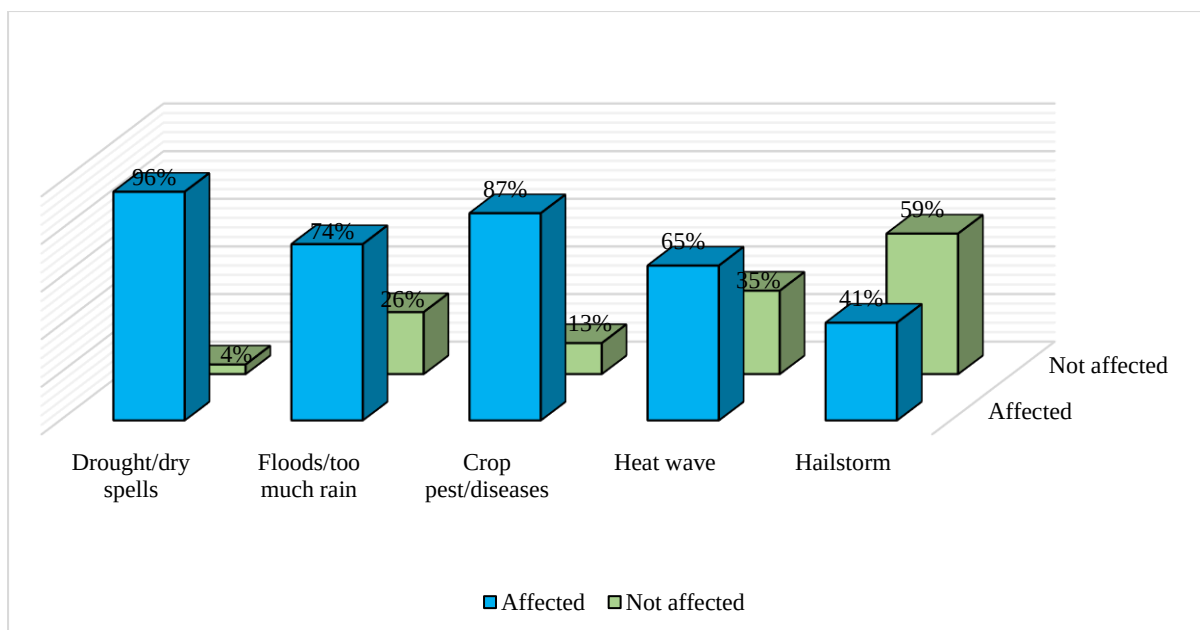


Figure 4. 1: Climatic shocks/stresses affecting bean production and other crops

Table 4. 4: Gendered perspective of effects of climate shocks/stresses on bean production and other crops

Climate shock/stress	Female			Male			Chi2
	Affected	Not affected	N	Affected	Not affected	N	
Drought/dry spells	226(96)	9(4)	235	117(97)	4(3)	121	NS
Floods/too much rain	177(75)	58(25)	235	88(73)	33(27)	121	NS
Crop pests/diseases	199(85)	36(15)	235	112(93)	9(7)	121	S
Heat wave	151(64)	84(36)	235	83(69)	38(31)	121	NS
Hailstorm	112(48)	123(52)	235	39(32)	82(68)	121	S

Note: Percentages in parenthesis

4.5.1.4.2 Perceived severity of climate shock/stresses on livelihoods and bean production in the past 10 years

With reference to [Table 4.5](#), the first row indicates approximately 71 percent of respondents perceived extremely severe effects of drought/dry spells, 56 percent floods/too much rains (second row), 52 percent crop pests/ diseases (third row), 23 percent hailstorms (fourth row), and 51 percent heat wave (fifth row) on their livelihoods and common bean production in the past 10 years. Overall, in the sixth row of Table 4.5 approximately 51 percent of the farmers perceived extremely severe effects of climatic shocks/stresses. By contrast, approximately 28 percent perceived no severe effects of climatic shocks/stresses on their livelihoods and bean

production. This result is consistent with [Chinsinga & Chasukwa \(2018\)](#) who asserts that over recent years Malawi has been suffering from several droughts and floods. Further, [Giertz *et al.* \(2015\)](#), reported that the damaging impact of pests and diseases is significant but depends on agricultural practices and mitigation activities. The impact of pests and diseases are at times also exacerbated by adverse weather events. Erratic rainfall and hailstorms are frequent, but of moderate or low impact. In terms of gendered perceived severity of climatic shocks/stresses on common bean production, the results show statistically insignificant perceptions on severity of droughts/dry spells, floods/too much rain, crop pests/diseases, and heat wave (Table 4.6). However, perception of male and female respondents on severity of hailstorm on bean production show statistical significance with more female respondents (26 percent) perceiving extreme severe effect of hailstorm than male respondents (17 percent).

Table 4. 5: Effects of climatic shocks and stresses on common bean production at farm household level over the past 10 years

Climate shock/stress	Extremely severe	Severe	Neutral	Not severe	Extremely Not severe/ irrelevant
Droughts/ dry spells	252(71)	40(11)	6(2)	43(12)	15(4)
Floods/too much rain	198(56)	33(9)	6(2)	23(6)	96(27)
Crop pest/diseases	185(52)	55(16)	19(5)	47(13)	50(13)
Hailstorms	82(23)	20(6)	14(4)	28(8)	212(59)
Heat waves	186(51)	27(8)	5(1)	16(5)	125(35)
Overall	180(51)	35(10)	10(3)	31(9)	100(28)

Note: $n = 356$. Percentages in parenthesis

Table 4. 6: Gendered farmers perspective of severity of climatic shocks/stresses on bean production

Climate shock/stress	Gender	Extremely severe	Severe	Neither severe nor not severe	Not severe	Extremely not severe	<i>n</i>	Chi2
Drought/dry spells	Female	174(74)	24(10)	5(2)	22(9)	10(4)	235	NS
	Male	78(65)	16(13)	1(1)	21(17)	5(4)	121	
Floods/too much rain	Female	134(57)	25(11)	3(1)	14(6)	59(25)	235	NS
	Male	64(53)	8(7)	3(3)	9(7)	37(31)	121	
Crop pests/diseases	Female	125(53)	35(15)	8(3)	30(13)	37(16)	235	NS
	Male	60(50)	20(17)	11(9)	17(14)	13(11)	121	
Heat wave	Female	118(50)	19(8)	5(2)	8(3)	85(36)	235	NS
	Male	65(54)	8(7)	0	8(7)	40(33)	121	
Hailstorm	Female	61(26)	18(8)	11(5)	17(7)	128(55)	235	S
	Male	21(17)	2(2)	3(3)	11(9)	84(69)	121	

Note: Percentages in parenthesis

4.5.1.5 Farmers perceived effects of climate variability and change on crops, humans, and livestock

This section presents farmers' perceived effects of decreased rainfall, increased temperature, increased incidences of pest and diseases, strong winds and droughts on crops, humans and livestock as a result of varying and changing climate.

4.5.1.5.1 Decreased rainfall

The results in the second, third, and fourth row of Table 4.7 indicate the majority of respondents perceived hunger, food insecurity, loss of livelihoods, loss of seed and crop, and lack of fodder, and livestock deaths are as a result of decreased rainfall, unpredictable rainfalls and breaks in rainy seasons, early and late rains. This is evidenced by the respondents' level of agreement to perceived impacts.

4.5.1.5.2 Increased temperature

With reference to sixth, seventh, and eighth rows of Table 4.7, the majority of respondents perceived hunger, food insecurity, and loss of livelihoods, lack of fodder, and livestock deaths, loss of crops, and seed, as a consequence of increased temperature due to the varying and changing climate.

4.5.1.5.3 Increased incidences of pest and diseases

Looking at the tenth, eleventh, and twelfth rows of [Table 4.7](#), a clear majority of respondents perceive human sickness, deaths and low livestock production, and poor yields and loss of crops are as result of increased incidences of pest and diseases due to the varying and changing climate.

4.5.1.5.4 Other effects (strong wind and droughts)

Results in fourteenth, fifteenth, sixteenth and seventeenth rows of [Table 4.7](#) indicate the majority of respondents perceive falling of cultivated crops, hunger, food insecurity and loss of livelihoods, lack of fodder and livestock deaths, loss of crops and seed are as a result of other factors, i.e., strong winds and drought, due to the varying and changing climate. These results suggest that strong winds and droughts impact on smallholder farming communities and pose a great threat to humans, crops and livestock.

Table 4. 7: A two-way frequency table of farmers perceived effects of climate variability and change on crops, humans, and livestock.

Effects of climate change	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
<i>Decreased rainfall</i>					
Hunger, food insecurity and loss of livelihoods	6(2)	3(1)	1(0)	124(35)	222(62)
Loss of crops	6(2)	3(1)	2(0)	147(41)	198(56)
Lack of fodder and livestock deaths	10(3)	44(12)	4(1)	111(31)	187(53)
<i>Increased temperature</i>					
Hunger, food insecurity and loss of livelihoods	6(2)	25(7)	7(2)	113(32)	205(57)
Lack of fodder and livestock deaths	12(3)	37(10)	3(1)	112(32)	192(54)
Loss of crop, and seed	5(1)	15(4)	4(1)	147(41)	185(52)
<i>Increased incidences of pest and diseases</i>					
Human sickness	9(3)	44(12)	9(3)	109(30)	185(52)
Deaths and low livestock production	3(1)	19(5)	2(0)	126(35)	206(58)
Poor yields and loss of crops	2(0)	1(0)	2(0)	137(39)	214(60)
<i>Others</i>					
Strong winds-falling of cultivated crops	2(0)	4(1)	2(0)	132(37)	216(61)
Droughts-hunger, food insecurity, and loss of livelihoods	1(0)	1(0)	1(0)	140(39)	213(60)
Droughts-lack of fodder and livestock deaths	8(2)	34(9)	3(1)	109(31)	202(57)
Drought-loss of crop and seed	1(0)	1(0)	2(1)	157(44)	195(55)

Note: $n = 356$ and Percentages in parenthesis

4.5.1.6 Gender perspective of farmers' general perceptions of climate variability and change

The results in Table 4.8, narrate the gendered perceptions of climate variability and change. Referring to the first row of Table 4.8, the majority of respondents perceive that men and women are equally affected by climate variability and change. This assertion is supported by 68 percent of respondents (33 percent 'agree', and 35 percent 'strongly agree'). By contrast, 33 percent of respondents perceive that men and women are affected differently with climate variability and change. This is evident by 17 percent of the respondents that 'disagree', and 15 percent that 'strongly disagree' to the assertion that men and women are affected the same with climate variability and change. However, looking at first row of Table 4.9, the perception of

male and female respondents on the assertion that men and women are affected the same by climate variability and change show statistically insignificant result.

In terms of how men and women respond to climate variability and change, the results show approximately 63 percent of respondents perceive the same response to climate variability and change between men and women. This is evident by 40 percent of the respondents that ‘agree’ and 23 percent that ‘strongly agreed’ to the assertion that men and women respond the same to climate variability and change. By contrast, 35 percent of respondents perceive there are differences in the way men and women respond to climate variability and change. This is supported by 23 percent of the respondents that ‘disagree’, and 12 percent that ‘strongly disagree’ to affirmations and indicated that response to climate variability and change at farm level are different between men and women. Referring to the second row of Table 4.9, the perception of male and female respondents on the affirmation that men and women respond the same to climate variability and change are statistically insignificant.

For access to climate change information, approximately 74 percent of respondents perceive the same access to information between men and women. This is supported by the 43 percent of respondents that ‘agree’ and 31 percent that ‘strongly agree’ to the statement that both men and women have the same access to climate change information at household level. However, 26 percent of the respondents perceive men and women do not have the same access to climate variability and change information. This is evident by 18 percent of the respondents that ‘disagree’ and 8 percent that ‘strongly disagree’ to the affirmations and indicate they perceive men and women do not have the same access to climate change information. With respect to perception of male and female respondents, the results show statistical insignificance to assertions (Table 4.9).

User friendliness of climate change adaptation strategies is perceived the same between men and women by approximately 69 percent of the respondents (49 percent ‘agree’ and 20 percent ‘strongly agree’). By contrast, 27 percent of the respondents (17 percent ‘disagree’ and 10 percent ‘strongly disagree’) perceive differences in the user friendliness of climate change adaptation strategies. Considering the fourth row of Table 4.9, the results show statistical insignificance on the perceived assertion of user friendliness of adaptation strategies to climate variability and change between male and female respondents.

Joint decision-making on the choice of adaptation strategies between men and women is supported by approximately 85 percent of respondents (60 percent ‘agree’ and 25 percent

‘strongly agree’). By contrast, 11 percent of the respondents (7 percent ‘disagree’ and 4 percent ‘strongly disagree’) perceive choices of climate adaptation strategies are not made jointly between husband and wife, others are neutral (neither agree nor disagree) to the affirmations. The results further indicate statistical insignificance between male and female respondents on the statement that men and women make joint choices to adaptation strategies to climate change at household level.

Regarding how men and women exercise knowledge to deal with climate change, the results indicate that 88 percent of respondents (60 percent ‘agree’ and 28 percent ‘strongly agree’) perceive a balance in exercising knowledge to deal with climate change between men and women with only 8 percent of respondents (5 percent ‘disagree’ and 3 percent ‘strongly disagree’) that perceive unequal chances in exercising knowledge to deal with climate variability and change. Looking at the sixth row of Table 4.9, the result show that 33 percent of male respondents “strongly agreed”, and 64 percent “agreed” to the assertions that men and women have equal chances to exercise knowledge to deal with climate change. By contrast, 26 percent of female respondents “strongly agreed”, 59 percent “agreed”, and are statistically significant. This result suggests that the majority of male respondents perceived equal chances in exercising knowledge to deal with climate variability change than female respondents. This implies that female’s contribution to knowledge to deal with climate variability and change is slightly lower than male.

Considering the assistance received in times of climatic shocks and stresses, approximately 78 percent of the respondents (60 percent ‘agree’ and 28 percent ‘strongly agree’) perceive men and women receive equal assistance in an event of climate induced shocks/stresses. By contrast, 18 percent of the respondents (11 percent disagree and 7 percent ‘strongly disagree’) perceive men and women do not receive equal assistance in times of climatic shocks/stresses. In relation to male and female respondents’ perception, on equal assistance between men and women in times of climatic shocks/stresses, the result shows a statistical insignificance (seventh row of Table 4.9).

In accounting for how natural resources are destroyed between men and women, 38 percent of the respondents (14 percent agree, and 24 percent strongly agree) perceive no differences in the way men and women are involved in destroying natural resources. By contrast, the majority of the respondents (61 percent) perceive differences in the way men and women are involved in destroying natural resources. Considering the eighth row of Table 4.9, the results show

statistical insignificance on male and female perception of equal involvement in destroying natural resources.

For non-involvement of women in the choice of adaptation strategies, approximately 65 percent of the respondents (43 percent agree, and 22 percent strongly agree) perceive low crop yields at household level are attributable to non-involvement of women in choosing right adaptation strategies to climate change. By contrast, 31 percent of the respondents perceive that non-involvement of women in choosing climate adaptations strategies does not result in low crop yields. Despite these mixed perceptions, 4 percent of the respondents showed neutrality (neither agreed nor disagreed) in their perception to the affirmation. However, male and female perception to the affirmation is statistically insignificant.

As for women's inclusion of suggestion on tackling climate change, 55 percent of the respondents (39 percent agree, and 16 percent strongly disagree) perceive inclusion of women's suggestions on tackling climate change are not taken on board at household level. By contrast, 42 percent (33 percent disagree, and 9 percent strongly disagree) perceive women's propositions on tackling climate change are taken on board at household level. Referring to the tenth row of Table 4.9, female respondents support the assertion that women's suggestions in tackling climate change are not taken on board at household level as compared to male respondents and is statistically significant. This implies that ideas purported by females are not normally used in the process of tackling climate change, and if males suggestions are wrong means the farm household would be negatively affected by the impact of the changing climate and yet useful ideas are left unused within the household.

For the innovation in dealing with climate change, 63 percent of the respondents (45 percent agree, 18 percent strongly agree) perceive women's innovativeness in dealing with climate change is valued at household level. By contrast, 34 percent of the respondents (26 percent disagree, and 8 percent strongly disagree) perceive women's innovativeness is normally valued at household level in dealing with climate change. Looking at the eleventh row of Table 4.9, the majority of the female respondents support the affirmation that women's innovativeness in dealing with climate change is not valued at household level compared to male respondents and is significant. This implies that many households lose out on innovativeness of females within the household.

Women's inclusion in production decision-making is perceived to have the potential to improve households' food security (87 percent of the respondents - 49 percent agree, and 38

strongly agree). By contrast, 9 percent of the respondents (5 percent disagree, and 4 strongly disagree) perceive women's inclusion in production decision-making has no potential to improve food security at household level. The result shows a statistically insignificant perception of potential improvement on household food security due to women's inclusion in production decision-making in male and female respondents.

Table 4. 8: A two-way frequency table of farmers' gendered general perceptions of climate variability and change

Gendered statement of climate variability and change	Level of agreement (% bracket)				
	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Men and women are affected the same by climate change	125(35)	118(33)	0(0)	60(17)	53(15)
Same response to climate change between men and women	83(23)	142(40)	6(2)	80(23)	45(12)
Same access to information on climate change between men and women	109(31)	152(43)	1(0)	66(18)	28(8)
Adaptation strategies are user friendly to both men and women	72(20)	175(49)	10(3)	62(17)	37(10)
Men and women make adaptation strategy choices jointly at household level	88(25)	212(60)	16(4)	25(7)	15(4)
Both men and women have equal chances to exercise knowledge to deal with climate change	101(28)	215(60)	11(3)	19(5)	10(3)
Women and men are given equal assistance in an event of climate induces shocks/stresses	100(28)	177(50)	16(4)	38(11)	25(7)
Both men and women are involved equally in destroying natural resources	87(24)	52(14)	3(1)	112(32)	102(29)
Non-involvement of women in choosing right adaptation strategies to climate change results in low crop yields	78(22)	153(43)	15(4)	70(20)	40(11)
Women's suggestion on tackling climate change are not taken on board at household level	58(16)	139(39)	9(2)	117(33)	33(9)
Women's innovativeness in dealing with climate change is not valued at household level	65(18)	161(45)	11(3)	92(26)	27(8)
Women's inclusion in production decision-making would improve households' food security	136(38)	176(49)	12(3)	17(5)	15(4)

Note: $n = 356$. Percentages in parenthesis

Table 4. 9: General gendered perception of climate variability and change disaggregated by gender

Climate shock/stress	Gender	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	<i>n</i>	Chi2
Men and women are affected the same by climate change	Female	78(33)	79(34)	0(0)	39(17)	39(17)	235	NS
	Male	47(39)	39(32)	0(0)	21(17)	14(12)	121	
Same response to climate change between men and women	Female	51(22)	93(40)	6(3)	55(23)	30(13)	235	NS
	Male	32(26)	49(41)	0(0)	25(21)	15(12)	121	
Same access to information on climate change between men and women	Female	66(28)	96(41)	1(0)	50(21)	22(9)	235	NS
	Male	43(36)	56(46)	0(0)	16(13)	6(5)	121	
Adaptation strategies are user friendly to both men and women	Female	42(18)	111(47)	9(4)	45(19)	28(12)	235	NS
	Male	30(25)	64(53)	1(1)	17(14)	9(7)	121	
Men and women make adaptation strategy choices jointly at household level	Female	55(23)	136(58)	15(6)	20(9)	9(4)	235	NS
	Male	33(27)	76(63)	1(1)	5(4)	6(5)	121	
Both men and women have equal chances to exercise knowledge to deal with climate change	Female	61(26)	138(59)	11(5)	18(8)	7(3)	235	S
	Male	40(33)	77(64)	0(0)	1(1)	3(3)	121	
Women and men are given equal assistance in an event of climate induced shocks/stresses	Female	68(29)	109(46)	11(5)	28(12)	19(8)	235	NS
	Male	32(26)	68(56)	5(4)	10(8)	6(5)	121	
Both men and women are involved equally in destroying natural resources	Female	58(25)	35(15)	3(1)	70(30)	69(29)	235	NS
	Male	29(24)	17(14)	0(0)	42(35)	33(27)	121	
Non-involvement of women in choosing right adaptation strategies to climate change results in low crop yields	Female	47(20)	105(45)	13(6)	47(20)	23(10)	235	NS
	Male	31(26)	48(40)	2(2)	23(19)	17(14)	121	
Women's suggestion on tackling climate change are not taken on board at household level	Female	47(20)	95(40)	9(4)	70(30)	14(6)	235	S
	Male	11(9)	44(36)	0(0)	47(39)	19(16)	121	
Women's innovativeness in dealing with climate change is not valued at household level	Female	52(22)	104(44)	10(4)	57(24)	12(5)	235	S
	Male	13(11)	57(47)	1(1)	35(29)	15(12)	121	
Women's inclusion in production decision-making would improve households' food security	Female	92(39)	113(48)	11(5)	11(5)	8(3)	235	NS
	Male	44(36)	63(52)	1(1)	6(5)	7(6)	121	

Note: Figures outside the brackets are count, and in parenthesis are percentages

4.5.1.7 Decision-making on the use of climate change adaptation strategies at household level

This sub-section discusses decision-making on the use of adaptation strategies to climate variability and change in smallholder farming.

4.5.1.7.1 *Change in planting times*

With reference to the first row of Table 4.10, approximately 59 percent of the respondents reported that, in female-headed households, decisions on changes in planting times as an adaptation strategy to climate variability and change are made by household heads, while 10 percent reported that such decisions are made by spouses. There are others who have made a decision not to change planting time as an adaptation strategy to climate change and are represented by 31 percent of respondents. This result suggests that in total, approximately 69 percent of respondents have, at some time, changed planting times/dates as an adaptation strategy to climate variability and change.

By contrast, in male-headed households (first row), approximately 39 percent, 11 percent, and 12 percent of the respondents indicated that decision-making on changing planting times/dates are made by household heads, spouses, and both household head and spouse (joint) respectively. However, a certain proportion of the respondents made a decision not to change planting times/dates as an adaptation strategy (38 percent). Generally, 62 percent of the respondents indicated that they have used changing planting times/dates as an adaptation strategy to climate change with the decision on the use being made by either household heads, spouse or joint (household head and spouse).

Generally, across female and male-headed households, 43 percent, 10 percent, and 9 percent, of respondents indicated that decisions on changes in planting times/dates were made by household heads, spouses, and joint (household and spouse). However, 37 percent of respondents made a decision not to change planting times as an adaptation strategy to climate variability and change, therefore, rendering decision-making units not applicable. Overall, decisions on changes in planting times or dates are reported to be made by approximately 62 percent of the respondents. Looking at the first row of Table 4.11, approximately 57 percent of the male respondents reported that decisions on changes in planting times as an adaptation strategy to climate variability and change are made by males, while 36 percent of the female respondents indicated that such decisions are made by females and are significant. Furthermore, 16 percent of the female respondents reported that decisions on changes in

planting times are made by spouses. This result implies that decisions on changes in planting times as an adaptation strategy to the varying and changing climate are dominated by males.

4.5.1.7.2 Use of drought tolerant varieties

With regards to the second row of Table 4.10, approximately 46 percent and 12 percent of the respondents indicated that decisions on the use of drought tolerant varieties are made by household heads and spouses respectively, while 42 percent indicated they made a decision not to use drought tolerant varieties as an adaptation strategy to climate variability and change. This suggests the majority of the respondents (58 percent) in female-headed households have used drought tolerant varieties as an adaptation strategy to climate variability and change at some time.

On the other hand, in male-headed households, about 38 percent of the respondents indicated that decisions on the use of drought tolerant varieties are made by household heads, 14 percent by spouses and 8 percent jointly (household heads and spouses). However, 40 percent of the respondents were not involved in making decisions on use of drought tolerant varieties as an adaptation strategy to climate change, as they have made a decision not to use. This suggests that a clear majority of respondents (60 percent) is involved in the use drought tolerant varieties as an adaptation to climate variability and change.

Overall, across both male and female-headed households, 40 percent, 13 percent, and 6 percent of the respondents indicated that decisions on the use of drought tolerant varieties as an adaptation strategy to climate change are made by household heads, spouses, and joint (household heads and spouses), respectively. The remaining proportion made a decision not to use drought tolerant varieties as an adaptation strategy to climate variability and change. Referring to the second row of Table 4.11, the statistically significant results indicate that 55 percent of the male respondents reported that decision-making on the use of drought tolerant varieties as an adaptation strategy to climate variability and change are made by males, while 32 percent of the female respondents reported that such decisions are made by females. In addition, 17 percent of the female respondents reported that such decisions are also made by spouses (males). This result implies that decision-making on the use of drought tolerant varieties are largely made by males and that females sometimes delegate decision-making on use of drought tolerant varieties.

In areas where droughts are normally prevalent, use of drought tolerant varieties is promoted to ensure that farmers still realize reasonable amounts of harvest or resist total crop loss (Chataika *et al.*, 2016).

4.5.1.7.3 Irrigation

With reference to the third row of Table 4.10, in female-headed households, approximately 64 percent of the respondents indicated that decisions on use of irrigation as an adaptation strategy at household level are made by household heads, and 10 percent by spouses. Nevertheless, 26 percent of respondents made a decision not to use of irrigation as an adaptation strategy to climate change. The result suggests a clear majority of respondents (74 percent) have ever used irrigation as an adaptation strategy to climate change.

By contrast, approximately 34 percent of the respondents reported that decisions on the use irrigation as an adaptation strategy in male-headed households were made by household heads, 18 percent by spouses, 13 percent household heads and spouses, while 35 percent of the respondents reported that they made a decision not to use irrigation as an adaptation strategy to the varying and changing climate.

Across male and female-headed households, 41 percent of the respondents indicated that decisions on using irrigation as an adaptation strategy to climate change are made by household heads, 16 percent spouses, 10 percent joint, while 33 percent decided not to use irrigation as an adaptation strategy to climate change. The results in the third row of Table 4.11 indicate that 56 percent of the male respondents reported that decision-making on the use of irrigation as an adaptation strategy to climate variability and change are made by males and are significant. By contrast 33 percent of the female respondents reported that such decisions are made by females. Furthermore, female respondents also reported that decisions on the use of irrigation are made by spouses. This result suggests that decision-making on the use of irrigation as an adaptation strategy is normally made by males.

4.5.1.7.4 Use of soil and water conservation measures

With reference to the fourth row of Table 4.10, in female-headed households, approximately 28 percent of the respondents reported that decisions on the use of soil and water conservation measures were made by household heads, and 10 percent by spouses. However, 62 percent of the respondents made a decision not to use soil and water conservation measures as an adaptation strategy to climate variability and change.

By contrast, in male-headed households, approximately 30 percent of the respondents reported that decisions on use of soil and water conservation measures were made by household heads, 7 percent by spouses, and 5 percent by household heads and spouses jointly. A larger proportion of the respondents (58 percent) have made a decision not to use soil and water conservation measures as adaptation strategies to climate variability and change.

Referring to the fourth row of Table 4.10, 29 percent of the respondents across male- and female-headed households indicated that decisions on soil and water conservation measures as adaptation strategies to climate variability and change were made by household heads, 7 percent by spouses, and 4 percent by household heads and spouses jointly. While 60 percent of the respondents have decided not to use soil and water conservation measures as adaptation measures to climate change. With regard to the fourth row of Table 4.11, 49 percent of the male respondents reported that decision-making on soil and water conservation measures as an adaptation strategy to climate change is done by males, while 19 percent of the female respondents reported that such decisions are made by females and are significant. Again, this result suggests the dominance by males in decision-making on soil and water conservation measures as an adaptation strategy.

4.5.1.7.5 Intensive use of chemical fertilizers

Looking at the fifth row of Table 4.10, in female-headed households, 30 percent of the respondents reported that decisions on intensive use of chemical fertilizers are made by household heads, and 1 percent by spouses. However, a clear majority (69 percent) of the respondents made a decision not to practice intensive use of chemical fertilizer as an adaptation strategy to climate variability and change.

On the other hand, in male-headed households, approximately 18 percent of the respondents indicated that decisions on intensive use of chemical fertilizer to common beans and as an adaptation strategy to climate change are made by household heads, 11 percent by spouses, and

7 percent by household heads and spouses jointly, while 64 percent of the respondents decided not to practise intensive use of chemical fertilizer as an adaptation to climate variability change.

Overall, across male and female-headed households, about 20 percent of the respondents indicated that decisions on use of chemical fertilizer were made by household heads, 9 percent by spouses, and 6 percent by household heads and spouses jointly. Finally, 65 percent of the respondents made decisions not to practise intensive use of chemical fertilizer in bean production possibly because of common bean capacity to fix atmospheric nitrogen. In terms of who makes the decision on intensive use of chemical fertilizer as an adaptation strategy to climate change between males and females, the fifth row of Table 4.11 indicates that 27 percent of the male respondents reported that males are responsible for such, while 19 percent of the female respondents reported that such decisions are made by females. This result clearly suggests male dominance in decision-making on intensive use of chemical fertilizer.

4.5.1.7.6 Crop rotation

The sixth row of Table 4.10 indicates that in female-headed households, approximately 42 percent and 11 percent of the respondents reported that decisions on practising crop rotation are made by household heads and spouses, respectively. However, 47 percent of the respondents decided not to practice crop rotation as an adaptation strategy to climate change.

Notwithstanding, in male-headed households, about 38 percent of the respondents indicate that decisions on practising crop rotation are made by household heads, 15 percent by spouses, and 8 percent by household heads and spouses jointly. Besides, around 39 percent of respondents made a decision not to practice crop rotation as an adaptation strategy to climate change.

In general, across male and female-headed households, approximately 39 percent, 14 percent and 6 percent of the respondents reported that decisions on practising crop rotation are made by household heads, spouses, and both household heads and spouses, respectively. However, 41 percent of the respondents made a decision not to practice crop rotation as adaptation strategies to climate change partly because of scarcity of land. In terms of who makes decisions between males and female on practising crop rotation as an adaptation strategy, the sixth row of Table 4.11 shows that 65 percent of the male respondents reported that such decisions are made by males, while 25 percent of the female respondents indicated that such decisions are made by females. This result clearly suggests that males take a lead in decision-making on practising crop rotation.

4.5.1.7.7 Fallowing

With reference to row seven of Table 4.10, in female-headed households, approximately 6 percent of the respondents indicated that decisions on fallowing the crop fields in female-headed households are made by household heads. However, the majority of the respondents (94 percent) made a decision not to fallow their pieces of land.

By contrast, in male-headed households, 11 percent, 2 percent, and 1 percent of the respondents indicated that decisions on fallowing are made by household heads, spouses, and household heads and spouses jointly, respectively. On the other hand, about 85 percent of the respondents decided not to fallow their land as an adaptation strategy to climate change.

Overall, across male, and female-headed households, approximately 10 percent, 2 percent, and 1 percent of the respondents reported that decisions on fallowing at household level are made by household heads, spouses, and joint (household heads and spouses) respectively. However, approximately 87 percent of the respondents made a decision not to practice fallowing as an adaptation strategy to climate variability and change. This could be attributed to scarcity of and ownership of land. Considering who makes decisions on land fallowing as an adaptation strategy between male and female respondents, the results in the seventh row of Table 4.11 show that 20 percent of the male respondents reported that such decisions are made by males, while 5 percent of the female respondents reported that such decisions are made by females. This result clearly suggests that males are in the forefront making decision on field/land fallowing as an adaptation strategy.

4.5.1.7.8 Non-farm activities

In the eighth row of Table 4.10, in female-headed households, approximately 27 percent, 7 percent, and 1 percent of the respondents reported that decisions on engaging in non-farm activities as an adaptation strategy to climate change are made by household heads, spouses, joint (household heads and spouses) respectively. Nevertheless, 65 percent of the respondents made a decision not to embark on non-farm activities as an adaptation strategy to climate change.

On the other hand, in male-headed households, around 28 percent, 11 percent, and 8 percent of the respondents reported that decisions on engaging in non-farm activities as an adaptation strategy to climate change are made by household heads, spouses, and joint respectively. In the

same vein, 53 percent of the respondents decided not use non-farm activities as an adaptation strategy to climate variability and change.

Largely, across male and female-headed households, approximately 28 percent of the respondents indicated that decisions on use of non-farm activities are made by household heads, 10 percent by spouses, and 6 percent by both household heads and spouses (joint). However, 56 percent of the respondents made a decision not use non-farm activities as an adaptation strategy to climate variability and change. This could be attributed to lack of income generating activities and availability of informal employment or business opportunities. The results in the eighth row of Table 4.11 further indicate that decision-making on non-farm activities as an adaptation strategy to climate change are made by males, and this is supported by 39 percent of the male respondents. By contrast, 22 percent of the female respondents indicated that non-farm activity decisions are made by females. This result suggests differences in decision-making on non-farm activities between males and females, with males having an upper hand.

4.5.1.7.9 Early maturing varieties

Considering the ninth row of Table 4.10 in female-headed households, 54 percent of the respondents reported that decisions on use of early maturing varieties are made by household heads, and 15 percent by spouses. However, 31 percent of respondents decided not to use early maturing varieties as an adaptation strategy to climate variability and change.

By contrast, in male-headed households, approximately 39 percent of the respondents reported that decisions on use of the adaptation strategy are made by household heads, 17 percent by spouses, and 11 percent by joint. However, 33 percent made a decision not use early maturing varieties as an adaptation strategy to climate variability and change.

In both male and female-headed households, approximately 42 percent of the respondents reported that decisions on use of early maturing varieties are made by household heads, 16 percent by spouses, and 8 percent joint. However, 33 percent of respondents made a decision not to use early maturing varieties as an adaptation strategy to climate variability and change. However, in general, 32 percent of the household heads, 11 percent spouses, 6 percent joint are perceived to be involved in decision-making on the use adaptation strategies while 50 percent are perceived not involved.

Finally, the last row of Table 4.10 shows that 32 percent of the respondents reported that decisions across different adaptation strategies are made by household heads, 11 percent by spouses, and 6 percent jointly. However, 50 percent made a decision not to use any other adaptation strategy to climate variability and change. Looking at the ninth row of Table 4.11, 60 percent of the male respondents reported that decisions on use of early maturing varieties as an adaptation strategy are made by males, while 34 percent of the female respondents reported that such decisions are made by females and are significant. This result suggests a clear male majority in decision making on the use early maturing varieties as an adaptation strategy.

Decision making on the use of adaptation strategies are directly related to factors that influence agricultural technology adoption and can be grouped into three broad categories (1) factors related to the characteristics of producers i.e. the farmers; (2) factors related to the characteristics and relative performance of the technology and (3) program and institutional factors (Bandiera & Rasul, 2006; Di Falco & Bulte, 2011; Doss, 2006; Feder *et al.*, 1985; Teklewold *et al.*, 2013; Yu *et al.*, 2010). The factors related to the characteristics of producers include education level, experience with the activity, age, gender, level of wealth, farm size, plot characteristics, labour availability, resource endowment, risk aversion, etc. The factors related to the characteristics and performance of the technology and practices include food and cash generation functions of the product, the perception by individuals of the characteristics, complexity and performance of the innovation, its availability and that of complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of recovery of investment, local adoption patterns of the technology, the susceptibility of the technology to environmental hazards, etc. The institutional factors include availability of credit, the availability and quality of information on the technologies, accessibility of markets for products and inputs factors, the land tenure system, and the availability of adequate infrastructure, extension support, etc. Enabling policies and programs, market linkages, access to institutional support and credit were found to play a positive role in stimulating farmer investment in and adoption of sustainable technologies (Shiferaw *et al.*, 2009). The subsequent section presents the logit regressions of farmers' perceptions of climate variability and change.

Table 4. 10: A two-way table of decision-making on the use of climate variability and change adaptation strategies at household level

Adaptation strategies	Decision-making on adaptation strategies at household level					
	Self/household head	Spouse	Joint	Other household members	Others	Not applicable
<i>Female-headed household</i>						
Change in planting	48(59)	8(10)	0(0)	0(0)	0(0)	27(31)
Drought tolerant varieties	38(46)	10(12)	0(0)	0(0)	0(0)	35(42)
Irrigation	53(64)	8(10)	0(0)	0(0)	0(0)	22(26)
Soil and water conservation measures	23(28)	8(10)	0(0)	0(0)	0(0)	52(62)
Use of chemical fertilizer	25(30)	1(1)	0(0)	0(0)	0(0)	57(69)
Crop rotation	35(42)	9(11)	0(0)	0(0)	0(0)	39(47)
Fallowing of crop fields	5(6)	0(0)	0(0)	0(0)	0(0)	78(94)
Non-farm activities	22(27)	6(7)	1(1)	0(0)	0(0)	54(65)
Early maturing varieties	45(54)	12(15)	0(0)	0(0)	0(0)	26(31)
<i>Male-headed household</i>						
Change in planting	106(39)	29(11)	32(12)	1(0)	1(0)	104(38)
Drought tolerant varieties	103(38)	37(14)	22(8)	1(0)	1(0)	109(40)
Irrigation	92(34)	48(18)	36(13)	0(0)	2(1)	95(35)
Soil and water conservation measures	81(30)	19(7)	12(5)	0(0)	0(0)	160(58)
Use of chemical fertilizer	48(18)	30(11)	20(7)	0(0)	0(0)	195(64)
Crop rotation	103(38)	41(15)	22(8)	0(0)	0(0)	106(39)
Fallowing of crop fields	31(11)	6(2)	3(1)	0(0)	0(0)	233(85)
Non-farm activities	76(28)	31(11)	22(8)	0(0)	0(0)	144(53)
Early maturing varieties	106(39)	45(17)	29(11)	2(1)	1(0)	90(33)
<i>Decisions by both male and female-headed households on individual strategy</i>						
Change in planting	154(43)	37(10)	32(9)	1(0)	1(0)	131(37)
Drought tolerant varieties	141(40)	47(13)	22(6)	1(0)	1(0)	144(40)
Irrigation	145(41)	56(16)	36(10)	0(0)	2(1)	117(33)
Soil and water conservation measures	104(29)	27(7)	13(4)	0(0)	0(0)	212(60)
Use of chemical fertilizer	73(20)	31(9)	20(6)	0(0)	0(0)	232(65)
Crop rotation	138(39)	50(14)	22(6)	0(0)	0(0)	145(41)
Fallowing of crop fields	36(10)	6(2)	3(1)	0(0)	0(0)	311(87)
Non-farm activities	98(28)	37(10)	23(6)	0(0)	0(0)	198(56)
Early maturing varieties	151(42)	57(16)	29(8)	2(1)	1(0)	116(33)
<i>Overall</i>						
Decisions across strategies	116(32)	39(11)	22(6)	0(0)	1(0)	198(50)

Note: N=356

Figures outside the brackets are count, and in parenthesis are percentages

Table 4. 11: Decision-making on use of adaptation strategies to climate change disaggregated by gender

Climate shock/stress	Gender	Self	Spouse	Joint	Other household members	Others	Not applicable	<i>n</i>	Chi ²
Change in planting	Female	85(36)	37(16)	22(9)	1(0)	0(0)	90(38)	235	S
	Male	69(57)	0(0)	10(8)	0(0)	1(1)	41(34)	121	
Drought tolerant varieties	Female	74(32)	41(17)	15(6)	1(0)	1(0)	103(44)	235	S
	Male	67(55)	6(5)	7(6)	0(0)	0(0)	41(40)	121	
Irrigation	Female	77(33)	53(23)	24(10)	0(0)	1(0)	80(34)	235	S
	Male	68(56)	3(3)	12(10)	0(0)	1(1)	37(31)	121	
Soil and water conservation measures	Female	45(19)	26(11)	10(4)	0(0)	0(0)	154(66)	235	S
	Male	59(49)	1(1)	3(3)	0(0)	0(0)	58(48)	121	
Use of chemical fertilizer	Female	40(17)	30(13)	13(6)	0(0)	0(0)	152(65)	235	S
	Male	33(27)	1(1)	7(6)	0(0)	0(0)	80(66)	121	
Crop rotation	Female	59(25)	50(21)	13(6)	0(0)	1(0)	112(48)	235	S
	Male	79(65)	0(0)	9(7)	0(0)	0(0)	33(27)	121	
Fallowing of crop fields	Female	12(5)	6(3)	2(1)	0(0)	0(0)	215(92)	235	S
	Male	24(20)	0(0)	1(1)	0(0)	0(0)	96(79)	121	
Non-farm activities	Female	51(22)	36(15)	16(7)	0(0)	0(0)	132(56)	235	S
	Male	47(39)	1(1)	7(6)	0(0)	0(0)	66(55)	121	
Early maturing varieties	Female	79(34)	52(22)	20(9)	2(1)	1(0)	81(35)	235	S
	Male	72(60)	5(4)	9(7)	0	0	35(29)	121	

Note: Figures outside the brackets are count, and in parenthesis are percentages. S (significant)

In a nutshell, the results indicate dominance of males in decision-making on the use of adaptation strategies to climate variability and change i.e., changes in planting times, use of drought tolerant varieties, irrigation, soil and water conservation measures, use of chemical fertilizers, crop rotation, land fallowing, non-farm activities and early maturing varieties. This result suggests that there is little contribution of females in decision-making on the use of adaptation strategies at farm household level.

4.5.2 Logit regressions of farmers' perception of climate variability and change in the study areas

4.5.2.1 Binary logit regressions of farmers' perceptions of the changing climate.

Table 4.12 presents the marginal effects on the binary logits of farmers' perceptions of climate variability and change. Some of the climate change indicators have been used to model the dependent variables, i.e., amount of the main rainfall season, onset of the main rainfall season, ending of the main rainfall season, and temperature changes in the past 10 years. The farmers' perceptions of these climate change indicators have been modelled as dichotomous. For instance, change in the main rainfall season can be perceived as (1= increase in the amount of main rainfall season, and 0 = decrease in the main rainfall season), onset of main rainfall season (1 = early onset, and 0 = late onset), ending of the main rainfall season (1=early ending, and 0 = late ending) and temperature changes in the past 10 years (1 increase in temperature, and 0 = decrease in temperature). Therefore, these dependent variables have been constructed using Questions 3.1.2, 3.1.4, 3.1.6, and 3.1.8 in Section 3 of the survey questionnaire presented in appendix 1. Details of the explanatory variables are outlined and explained in Section 4.4 in Table 4.1.

Looking at the third row and the second column of Table 4.12, for every additional farm household head group membership by one unit, the household head is more likely to perceive increases in the amount of the main rainfall season given that all the other variables in the model remain constant. This finding is consistent with [Gadédjisso-tossou \(2015\)](#) who found that being members of the farmers' associations or groups among others influence positively farmers' perception of changes in the climate.

For bean farming experience, for every additional year of bean farming experience, the household head is more likely to perceive increases in the amount of the main rainfall season and less likely to perceive early ending of the main rainfall season. This suggests that the more years the farmers have been growing common bean, the greater the accumulated experience of the amount and ending of the main rainfall season characterized by high amounts and late ending respectively. This result conforms to the work by [Gadédjisso-tossou \(2015\)](#) who found that farming experience seems to decrease the probability that the farmers will perceive long term changes in the rainfall. Further, this finding contradicts the work by [\(Karki et al., 2020\)](#) who found that farmers throughout the global have been experiencing changes in climate mainly regarding unpredictable and reduced rainfall.

The results further show that for every additional member in farm household, the perception of early onsets and early ending of the main rainfall season is more likely. This result implies that bigger farm households are more optimistic about the onset, and pessimistic about the ending of the main rainfall seasons. The perceptions of climate variability and change variables are sometimes influenced by individual's needs.

Table 4. 12: Marginal effects of binary logit regression models on farmers' perception of rainfall characteristics and temperature changes

Variable	Amount of main rainfall season	Onset of main rainfall season	Ending of main rainfall season	Temperature changes in the past 10 years
Marginal effects ($dE(y)/dx$)				
Age of household	-0.003(0.003)	-0.006(0.003)	-0.004(0.003)	0.000(0.002)
Land holding size	0.025(0.015)	0.010(0.019)	0.018(0.013)	-0.013(0.011)
Group membership	0.057*(0.020)	-0.002(0.026)	0.021(0.018)	-0.001(0.014)
Bean farming experience	0.005*(0.003)	0.003(0.004)	-0.009*(0.004)	0.002(0.002)
Family size	0.007(0.012)	0.034*(0.016)	0.024*(0.011)	-0.002(0.008)
Gender of household head	0.066(0.066)	-0.041(0.084)	-0.001(0.064)	-0.055(0.039)
Literacy	-0.030(0.060)	-0.166*(0.072)	-0.024(0.055)	0.015(0.040)
Climate awareness	-0.080(0.098)	0.023(0.121)	0.039(0.093)	-
Chikwawa	-0.094(0.064)	0.218*(0.089)	-0.094(0.059)	0.046(0.034)
Nsanje	-0.172*(0.061)	-0.023(0.089)	-0.108*(0.057)	0.163*** (0.039)
Zomba	-0.160*(0.061)	0.050(0.088)	-0.128*(0.059)	0.176*** (0.047)
Classification correctly predicted	76.6%	59.9%	79.9%	84.8%
LRChi ²	(11) = 27.96	(11) = 23.78	(11) = 21.42	(10) = 38.89
Log Likelihood	-159.18	-205.70	-149.18	-104.98
Pseudo R ²	0.08	0.05	0.07	0.16

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.0001$, ** < 0.01 , and * < 0.05

Dedza district as a reference category

Considering literacy levels, literate household heads are less likely to perceive early onsets of the main rainfall season. This result implies that educated farmers are aware of unpredictability of onsets of rainfall and that it does not have a significant trend.

Making reference to Dedza district, farm households in Chikwawa district are more likely to perceive early onsets of the main rainfall season. In Nsanje farm households are less likely to perceive increased amounts of the main rainfall season, and more likely to perceive increased temperature over the past 10 years. Finally, farm households in Zomba district are less likely to perceive increased amounts, early ending of the main rainfall seasons, and more likely to perceive increased temperature in the past 10 years. These results conform to the findings by (Kachaje *et al.*, 2016) who found a mixture of positive and negative trends for the monthly and seasonal precipitation with further indication of a decreasing annual rainfall variation and increasing temperature with time. These results are further supported by the findings from the focus group discussions of male, female and mixed group of participants held in the study sites. To avoid repetition, all the quotes in the findings chapters are contextualised based on gender of participants groups (e.g. male, female and mixed), age (ranging from 18-64 years), and livelihoods (farming). In these categories of participants' focus groups, local climatic indicators were perceived and discussed as follows:

“These days we are encouraged to join farmer associations/groups where there is a proper mix of experience, literacy levels and diversity. Through these group characteristics, the local climatic indicators i.e. amount of main rainfall season, is perceived to have decreased characterised by late starts, early stops and fluctuated rainfall seasons,, and temperature increases over the past 10 years.”

Within further discussion about what causes the fluctuations of rainfall and increased temperature, the discussants indicated that, *inter alia*, increased human population is posing pressure and competition on natural resources including trees, which are known to attract rainfall. In one of the female focus group discussions (FFGDs), one participant said:

“Due to high levels of poverty in this community, our husbands including us ‘women’ normally go uphill to burn charcoal for sale and cut down trees for construction of our shelters and firewood for sale, all these contribute to wanton destruction of the trees, she further mentioned that all these actions are done for survival sake, otherwise we would be going out most of the days without food in our households.”

There is a long list of causes of decreased rainfall and increased temperature as a result of climate variability and change, but what continuously surfaced in most of the discussions include weak by-laws on forest management, frequent use of chemicals to treat crop pest and diseases, continuous use of chemical fertilizers and continuous cultivation of the land.

Despite the majority of the farm households perceiving increase in temperature and decrease in amount of the main rainfall season (Table 4.2) over the past 10 years, the recorded meteorological data on temperature and rainfall from 2007 to 2019 show a slightly decreasing trend across all the study districts (Figure 4.2 and 4.3). Thus, farmers' perceptions of temperature changes appear not to be in accordance with the statistical record across the study districts. By contrast, farmers' perceptions on the amount of main rainfall season appear to be in accordance with the statistical record. Hence, smallholder farmers across these sites are well aware about changes in rainfall and not in temperature. These results conform to the findings by (Maddison, 2007) who found that some farmers' perceptions are as a result of placing more weight on recent information about temperature or rainfall over time than is realistic.

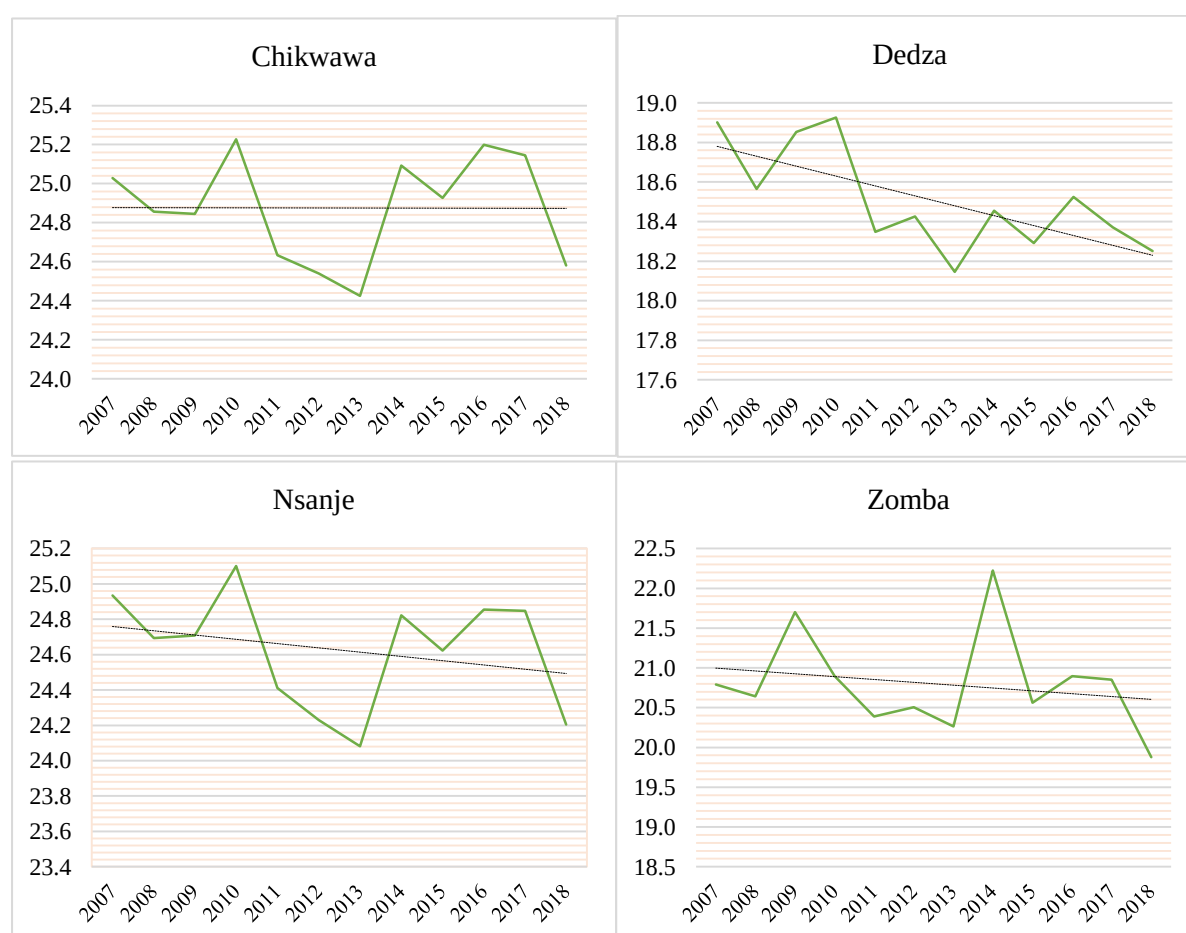


Figure 4. 2: Trend of mean annual temperature (°C) for a period running from 2007 to 2018

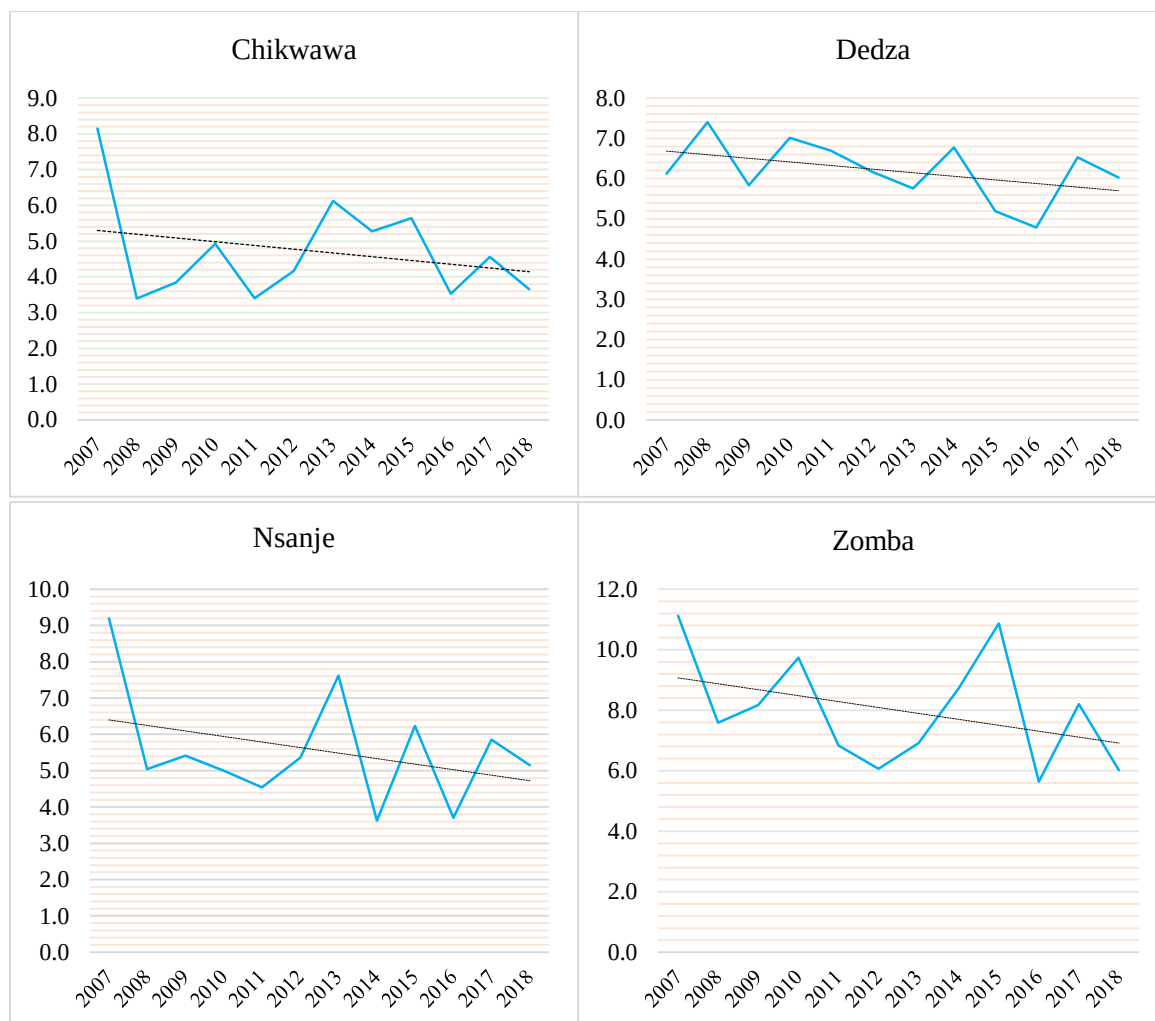


Figure 4. 3: Trend of mean annual rainfall (mm) for a period running from 2007 to 2018

From all the focus group discussions of trend analysis (MFGDsTA-male focus group discussions of trend analysis, FFGDsTA- female focus group discussions of trend analysis, and MxFGDsTA-mixed focus group discussions of trend analysis) using fixed periods of time (past 5-10 years, 10-15 years, and present) of aspects of climate related activities to establish changes over time and present, trend analysis results indicate normal seasonal rainfall characteristics in the past 10-15 years, moderate, and low seasonal rainfall characteristics. This is a clear indication that seasonal rainfall characteristics, specifically amount of main rainfall season, is perceived to be decreasing with time. By contrast, while the rainfall is perceived to be decreasing with time, temperature is perceived to be increasing with time. During the discussions from MFGDsTA, FFGDsTA and MxFGDsTA, the discussants said;

“Over the past 10-15 years and beyond, no farmer was worrying about rainfall. The growing calendar was normally predictable and normal for rainfall on-sets and off-sets, distribution and the amount. This helped preparation and planning for our farming activities. Recent trends (i.e. the past 5-10years), predictability of the growing calendar has been problematic but this is currently worse (i.e. at present). Similarly, temperature have changed, for example some month that used to be cold are becoming hot these days and visa-versa. These changes are so disturbing in planting which crops to plant or grow as some crops do well at certain moisture and temperature levels”.

Farmers’ knowledge of changes in climate variables is very important as it helps in preparing and adapting their farming activities to changes in order that their associated effects are minimised.

4.5.2.2 Marginal effects of ordered logistic regressions models of farmers’ future anticipation of the changing climate, and crop production in the past 10 years.

Table 4.13 presents the ⁸marginal effects of the ordered logistic regression models of anticipated future changes in rainfall, anticipated future changes in temperature, and crop production over the past 10 years. These dependent variables have been fashioned using questions 3.1.10, 3.1.11, and 3.1.12 of the survey questionnaire as presented in appendix 1. The respondents were asked about changes they anticipate regarding future rainfall, temperature, and changes in crop production over the past 10 years. The responses are pre-coded as (increase = 1, decrease = 2, no change = 3, and don’t know = 4).

Looking at the fourth row and fourth column of Table 4.13, for each additional year of household bean farming experience, the expected crop production change score in the past 10 years increases by 0.01 and is significant. This result suggests that farm households that have been growing common beans over the past 10 years have accumulated information about output and observed a decrease in crop production, probably due to the changing climate. This result conforms to findings by [Arora \(2019\)](#) who asserts that recent unprecedented increases in

⁸ The SE may be larger than the average marginal effects for significant variables in circumstances where the variable is highly significant in predicting a rise in some categories but not others. For example, variable may be insignificant with respect to predicting changes from levels 1, 2, 3 but highly significant for group 4 and 5. The significance of the coefficient in the latent regression will indicate that the variable had a significant marginal effect for at least some levels.

temperature have resulted in increased events of droughts, floods, irregular patterns of precipitation, heat waves and other extreme happenings throughout the globe, which have resulted into decreased crop yields. Further, higher temperature is estimated to have a negative impact on yields of major crops at the global scale (Zhao *et al.*, 2017).

The results from across the FGDs (MFGDs, FFGDs, and MxFGDs) discussions also indicate that the majority of the discussants perceived low recent crop yields compared to the past 10 years. Again, discussants from MFGDsTA-men focus group discussions of trend analysis, FFGTA-female focus group discussion of trend analysis, and MxFGDsTA-mixed focus group discussions of trend analysis said:

“In the past 10 years, we used to have big granaries filled with harvests of major crops including common beans, but recently this is a nightmare. In recent time, a lot of things have changed, our beautiful rivers which could flow water throughout the year just flow for a short while. This is generally affecting production of other crops which relied on irrigation and residual moisture. Our soils have been eroded heavily and some cultivable lands are full of gullies leaving the farmers with limited land to cultivate and consequently produce less.”

This suggests that farm households are worse off in terms of food security now compared to the past 10 years.

The results further indicate that farm households that are climate change aware are 0.45 less likely to anticipate increased future amounts of main rainfall seasons, and 1.36 less likely to anticipate increased future temperature. The result suggests that the more households are aware of climate change the less they anticipated future changes in rainfall and temperature. This result disagrees with the findings by (Kundu *et al.*, 2017) whose results showed increased amounts in the future rainfall, temperature and evapotranspiration projections.

In terms of geographical locations, the results indicate that, taking Dedza as the reference category, farm households in Zomba district are 0.42 less likely to anticipate increased future temperature. This result suggests that farm households in Zomba districts do not have a clear projection about the future changes of temperature, probably because of little or no change in the current temperature.

Table 4. 13: Marginal effects of ordered logistic regression models of perception of climate variability and change

Variable	Anticipated future changes in rainfall	Anticipated future changes in temperature	Crop production changes in the past 10 years
	Marginal effects ($dE(y)/dx$)		
Age of household head	0.002(0.009)	0.004(0.009)	-0.006(0.006)
Land holding size	0.057(0.052)	0.069(0.052)	-0.013(0.035)
Group membership	-0.036(0.072)	-0.015(0.068)	-0.037(0.045)
Bean farming experience	0.000(0.010)	0.004(0.010)	0.010***(0.007)
Family size	-0.010(0.042)	-0.003(0.040)	0.022(0.026)
Gender	-0.172(0.251)	-0.113(0.229)	-0.027(0.149)
Literacy	-0.174(0.215)	-0.032(0.191)	-0.039(0.129)
Climate change awareness	-0.448*(0.439)	-1.364*** (0.403)	-0.023(0.215)
Chikwawa	0.034(0.251)	0.107(0.239)	0.028(0.163)
Nsanje	-0.185(0.221)	-0.321(0.203)	-0.012(0.152)
Zomba	-0.012(0.243)	-0.421*(0.194)	0.028(0.161)
Classification accuracy (correctly predicted)	61.50 %	61.80 %	73.50 %
Log-likelihood	-316.91	-322.25	-259.28
LR Chi2	(11) = 73.68	(11) = 62.39	(11) = 111.59
Pseudo R2	0.151	0.171	0.146

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significance $p < 0.0001$, ** significance $p < 0.01$, and * significance $p < 0.05$

Dedza reference district category

4.5.2.3 Ordered logistic regression models of perceived effects of climatic shocks or stresses on bean production

Table 4.14 presents the marginal effects of perceived effects of shocks and stresses as a result of climate variability and change on crop production. The construction of the dependent variables was based on the questions in the survey questionnaire which asked respondents about the severity of climatic shocks or stresses. The survey questionnaire outlined the following climatic shocks and stresses: drought or dry spells, floods or too much rain, crop pests and diseases, hailstorms, and heat wave. The perceived effects of these climatic shocks and stresses were pre-coded as (extremely severe=1, very severe=2, Severe=3, significant=4, somewhat significant=5, Irrelevant=6, don't know=7) on a 1-7 scale (refer to questions 3.2.1B2 to 3.2.5B2 of the questionnaire in appendix 1).

Referring to the third row of Table 4.14, with an additional farm household head group membership, the household head is 0.14 more likely to perceive extremely severe effects of crop pests and diseases, and 0.24 heat wave on common bean production. This result implies that the more farm households increase their group membership base, their perception of the effects of climatic shocks and stresses, i.e., pest and diseases, and heat wave frequencies increase. This result is supported by the findings by [Nguyet \(2002\)](#) who affirms that information spreads more quickly when farmers are working together in a group and that different skills of farmers are better used, which helps shape their perceptions including that of climatic shocks and stresses.

Regarding literacy of household heads, literate household heads are 0.54 less likely to perceive extremely severe effects of heat wave on common bean crop production. This result indicates the negative relationship between literacy of farm household head and perceived effects of heat wave. Beyond climate related literature, this result is consistent with findings by [Fitzgerald *et al.* \(1991\)](#) who found a significant negative relationship between parental literacy level and perceptions of the importance of literacy of artefacts and events.

With regards to the study sites, the results indicate that, taking Dedza as a reference category, farm households in Chikwawa district are 0.52 less likely to perceive extremely severe effects of droughts/dry spells on common bean production. In Nsanje district, farm households are less likely to perceive extremely severe effects of floods/too much rain (in tenth row and third column of Table 4. 14), crop pests and diseases (fourth column of Table 4.14), heat wave (sixth column of Table 4.14), and more likely to perceive extremely severe effects of hailstorms. Finally, in the eleventh row of Table 4.14, the results indicate that farm households in Zomba district are less likely to perceive extremely severe effects of crop pests and diseases and heat wave, and more likely to perceive extremely severe effects of hailstorms. These results imply that there are negative relationships between perception of farm households in respective districts, and effects of climatic shocks and stresses. However, farm households in Nsanje and Zomba districts exhibit a positive relationship, i.e., perceived effects on hailstorms. These results conform to the findings by [Stephenson *et al.* \(2010\)](#) who found that, based on current climate change discourses that support the notion of climate change being human induced rather than natural phenomenon, climate change is driven more by consumer behaviour than by population numbers. Additionally, results from the focus group discussions indicate that

droughts or dry spells, floods and crop pests are among the prevalent climatic variables affecting smallholder farming.

Results cross trend analysis focus group (MFGDsTA-male focus group discussions of trend analysis, FFGDsTA-female focus group discussions of trend analysis, MxFGDsTA-mixed focus group discussions of trend analysis) discussions: One of the discussants in each group was supported unanimously by the group participants said:

“In the recent years, we have been continuously experiencing droughts, crop insect pest and disease attacks, and floods, in all these circumstances we are normally left without anything in our respective households, as our crops get completely scotched by heat during the drought periods, completely wiped out by notorious insect pests which come in form of a swarm and destroy all our crop fields, and again wash away and/or submerge all our crops as a result of heavy floods”.

Table 4. 14: Marginal effects of ordinal logistic regressions of perceived effects of climatic shocks or stresses on common bean production

Variables	Droughts/dry spells	Floods/too much rain	Crop pests and diseases	Hailstorms	Heat wave
	Marginal effects ($dE(y)/dx$)				
Age of household head	0.00(0.01)	-0.02(0.01)	0.00(0.01)	-0.01(0.02)	-1E-05(0.01)
Land holding size	0.02(0.04)	0.00(0.08)	0.05(0.05)	0.08(0.11)	0.00(0.09)
Group membership	0.08(0.05)	0.15(0.10)	0.14(0.06) *	0.04(0.13)	0.24(0.12) *
Bean farming experience	0.00(0.01)	0.00(0.01)	-0.01(0.01)	0.02(0.02)	0.00(0.02)
Family size	-0.05(0.03)	0.05(0.06)	-0.04(0.04)	0.03(0.07)	-0.05(0.07)
Gender	0.18(0.16)	0.28(0.29)	0.02(0.21)	-0.13(0.39)	0.39(0.35)
Literacy	-0.17(0.16)	-0.03(0.27)	-0.33(0.20)	0.06(0.34)	-0.54(0.33) *
Climate change awareness	0.28(0.20)	-0.10(0.45)	-0.42(0.33)	-0.08(0.55)	-0.20(0.51)
Chikwawa	-0.52**(0.15)	0.16(0.35)	-0.29(0.21)	-0.23(0.41)	-0.30(0.37)
Nsanje	-0.20(0.16)	-1.08*** (0.26)	-0.59* (0.20)	0.62(0.38) *	-1.49*** (0.28)
Zomba	-0.16(0.16)	-0.10(0.32)	-0.64**(0.19)	0.79** (0.35)	-1.54*** (0.27)
Model prediction	0.70	0.57	0.51	0.61	0.61
Log-likelihood	-296.30	-796.11	-415.29	-345.75	-326.51
LR Chi2	(11) = 60.09	(11) = 46.65	(11) = 49.48	(11) = 53.93	(11) = 61.91

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significance $p < 0.0001$, ** $p < 0.01$, and * $p < 0.05$

Dedza district reference category

4.5.2.4 Marginal effects of binary logit regressions models of farm households' decision on use of adaptation strategies to climate variability and change.

Table 4.15 presents the marginal effects of binary logit models of the adaptation strategies to climate variability and change used by smallholder farmers. The commonly used adaptation strategies used by smallholder farmers have been used to construct the dependent variables to understand their relationship with the independent variables which are detailed in Section 4.4 in Table 4.1.

The dependent variables include; changes in planting times (1 = change planting times, and 0 = otherwise), use of drought tolerant varieties (1 = use drought tolerant varieties, and 0 = otherwise), irrigation (1 = practice irrigation, and 0 = otherwise), soil and water conservation (1 = use soil and water conservation measures, and 0 = otherwise), use of chemical fertilizer (1 = use chemical fertilizers, and 0 = otherwise), crop rotation (1 = practice crop rotation, and 0 = otherwise), non-farm activities (1 = engage in non-farm activities, and 0 = otherwise), and early maturing varieties (1 = use early maturing varieties, and 0 = otherwise). The respondents were asked whether or not they have ever used outlined adaptation strategies to climate variability and change (Refer to questions 3.3.1C1 to 3.3.9C1 of the survey questionnaire in Appendix 1).

With reference to the third row of Table 4.15, for every additional household head group membership, the household heads are more likely to decide to use irrigation, less likely to use chemical fertilizers, more likely to practice crop rotation, and less likely to engage in non-farm activities as adaptation strategies to the changing climate. These results imply that increased group membership increases the chances to use irrigation, practice crop rotation, and decreases the chances to use chemical fertilizers and non-farm activities as adaptation strategies to climate variability and change in common bean farming. These results are consistent with the findings by Nakazi *et al.* (2017) who found that farmer groups/organizations are a strong basis upon which farmers can communicate their views, access technologies and information, and make necessary adjustments.

Regarding farming experience, for every additional year of household head bean farming experience, the household head is less likely to decide on the use of changes in planting times, drought tolerant varieties, and more likely to decide on the use of chemical fertilizers as adaptation strategies to climate variability and change increases by one unit, the expected

changes in planting time score decreases by 0.01, use of drought tolerant varieties score decreases by 0.01, and use of chemical fertilizers score increases by 0.01 as adaptation strategies to the changing and varying climate, and are significant. These results suggest that the accumulated experience by farmers over time help them establish when to plant, whether or not to use drought tolerant varieties, and use of chemical fertilizers based on trends. These results conform to the findings by [Ainembabazi & Mugisha \(2014\)](#) who found an inverted-U relationship between the adoption of, and experience with, agricultural technologies. Farming experience is also useful in early stages of adoption of a given technology when farmers are still trying its potential benefits, which later define its retention or dis-adoption over time.

Relating to the study districts, the results indicate that farm households in Chikwawa district (Dedza as reference category) are less likely to decide on the use of drought tolerant varieties, soil and water conservation measures, and early maturing varieties. Further, farm households in Nsanje district are less likely to decide on the use soil and water conservation measures, whereas farm households in Zomba district are more likely to use rotation as adaptation strategies to climate variability and change. The results show both negative and positive relationships with respect to some adaptation strategies and districts. This implies that the use of some adaptation strategies requires resources which most of the smallholder farmers are constrained, hence, use of such technologies become problematic. Further, where the technology (adaptation strategy) is less expensive it is expected to be used by the majority of the farmers. These results are consistent with the finding by [Muzamhindo et al. \(2015\)](#) who found that farmers with access to credit are able to adopt appropriate technologies and other farming practices in response to changes in climate. In addition, with financial resources, households can make use of the available information and the numerous adaptation options to respond to climate variability. These results are supported by the narratives from the MFGDs (male focus group discussions), as narrated by one of the discussants and that was supported unanimously:

“Due to unpredictability of rainfall onset and ending, we have now started adapting to changing planting dates by way of planting timing staggering. This allows for us to still coincide with the rightful planting rains. For persistent droughts and dry spells, where possible we use drought tolerant varieties given out by NGOs as we cannot afford the improved seed and embark on soil and water conservation measures to ensure moisture retention in crop fields, and

practising irrigation farming. Again, due to land pressure we engage in non-farm activities to secure some little cash to support our families. Further, not all of us are land scarce, some practise crop rotation to control pests and diseases”

Table 4. 15: Marginal effects of binary logit models of adaptation strategies to climate variability and change used by smallholder farmers

Variable	Changes in planting times	Drought tolerant varieties	Irrigation	Soil and water conservation	Use of chemical fertilizer	Practising crop rotation	Non-farm activities	Early maturing varieties
Age of household	0.005(0.003)	0.002(0.003)	-0.001(0.000)	0.004(0.003)	-0.005(0.004)	0.003(0.003)	-0.004(0.005)	-0.003(0.004)
Land holding size	-0.032(0.018)	-0.022(0.019)	0.011(0.018)	-0.005(0.020)	0.028(0.018)	0.045(0.022)	-0.019(0.019)	-0.007(0.020)
Group membership	-0.027(0.024)	-0.012(0.025)	0.056*(0.025)	-0.025(0.027)	-0.079*** (0.027)	0.035*(0.025)	-0.060*(0.026)	-0.001(0.013)
Bean farming experience	-0.009**(0.004)	-0.011**(0.004)	0.007(0.004)	-0.002(0.002)	0.009**(0.004)	-0.007(0.003)	-0.003(0.005)	0.003(0.003)
Family size	-0.018(0.015)	-0.001(0.015)	0.013(0.015)	0.015(0.015)	0.023(0.014)	0.006(0.015)	0.019(0.015)	-0.022(0.014)
Gender of household head	-0.052(0.079)	-0.080(0.080)	-0.101(0.075)	0.082(0.080)	0.071(0.078)	0.010(0.080)	-0.006(0.095)	0.008(0.079)
Literacy	0.107(0.068)	0.121(0.070)	0.076(0.067)	0.109(0.070)	-0.069(0.067)	0.029(0.069)	0.065(0.071)	0.175*(0.066)
Climate awareness	0.208(0.110)	0.187(0.114)	0.018(0.103)	0.012(0.114)	-0.081(0.108)	0.043(0.108)	0.150(0.112)	0.173(0.108)
Chikwawa	-0.117(0.089)	-0.216*(0.090)	0.067(0.081)	-0.181*(0.082)	-0.142(0.080)	0.033(0.083)	-0.057(0.088)	-0.269*(0.089)
Nsanje	0.007(0.086)	0.083(0.087)	-0.273(0.087)	-0.268*** (0.083)	-0.095(0.081)	0.056(0.083)	0.173(0.089)	-0.128(0.088)
Zomba	-0.073(0.088)	0.014(0.087)	0.079(0.085)	0.023(0.085)	-0.101(0.082)	0.200*(0.082)	0.000(0.089)	0.111(0.086)
LR Chi ²	(11)= 24.63	(11) = 30.12	(11) =46.01	(11) = 29.86	(11) = 27.80	(11) = 29.06	(11) = 22.16	(11) =41.74
Log Likelihood	-194.16	-196.6506	-176.13	-200.00	-193.16	-197.63	-207.81	-175.97
Classification accuracy (correctly predicted)	65.0 %	69.1 %	71.1 %	64.7 %	67.5 %	62.5 %	61.2 %	70.3
Pseudo R ²	0.17	0.18	0.22	0.17	0.16	0.18	0.15	0.21

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.0001$, ** $p < 0.01$, and * $p < 0.05$

Dedza district as the reference category

4.5.2.5 Ordered logistic regression (OLR) models of perceived effects of climate change on crops, humans, and livestock, and gender-based perspective of climate change.

Table 4.16 presents the marginal effects of ordered logistic models of perceived effects of climate variability and change on crops, humans and livestock. The dependent variables are constructed around the selected effects of climate variables captured in the survey questionnaire which include: decreased rainfall (Q4.2a to Q4.2c), increased temperature (Q4.2d to Q4.2f), increased incidences of pests and diseases (Q4.2k to Q4.2m), strong winds, and droughts/dry spells (Q4.2g to Q4.2j), and are measured on a 1-5 Likert scale (Refer to the survey questionnaire in appendix 1).

Looking at the second row of Table 4.16, the results indicate that, for every additional acre of land holding size, the expected perceived effects of drying of pasture, lack of fodder and livestock deaths as a result of increased temperature are less likely and significant. This result is plausible because relatively larger acreage of land can be planted to more pastures expecting to feed a good number of livestock for a reasonable amount of time, thereby subduing the effects of drying fodder, lack of fodder, and livestock deaths due to increased temperature as a result of the changing climate.

The results show that for every extra farm household group membership, the expected perceived effects of hunger, food insecurity, and loss of livelihoods, loss of crops and seed, lack of fodder, and livestock deaths, lack of fodder, and livestock deaths, human sickness, deaths and low livestock production, poor yields and loss of crops, increased incidences of pests and diseases are more likely and significant. Falling of cultivated crops is less likely due to decreased rainfall, increased temperature, increased incidences of pests and diseases, and strong winds and droughts or dry spells as a result of the varying and changing climate and is significant. These results imply that most of the effects of climate variability and change on crops, humans, and livestock are reduced due to increased household membership to groups in smallholder farming. This is conceivable because that there is always an increase in the knowledge base and information sharing in group participation as different groups have their own areas of focus, which may help tackle other ways of curbing the effects of climate variability and change, leaving the usual effects considered insignificant.

For family size, the results show that for every additional household member, the expected perceived effects of hunger, food insecurity and loss of livelihoods, and drying pasture, lack of

fodder and livestock deaths due to increased temperature as a result of the climate change are less likely and are significant. This result suggests that larger farm household sizes are less likely affected by the effects of climate variability and change. This is plausible because in times of climatic shocks and stresses, larger family sizes are more likely to provide more labour force for diversified ways of reducing the effects of the changing climate, i.e., off-farm activities, embarking into adaptation strategies, and lobbying for social safety nets (SSN).

With reference to literacy level of farm household heads, literate farm household heads are more likely to perceive the effect of lack of fodder and livestock deaths due to decreased rainfall and reductions in cultivated crops due to strong winds and droughts/dry spells. This result suggests that literate farm household heads are more likely to have access to information related to effects of decreased rainfall, strong winds and droughts/dry spells. Print media may include information of management of fodder, crops, livestock, and soil and water conservation measures to prepare or to adapt to the changes as a result of the changing climate.

For climate change awareness, farm household heads who are climate change aware are more likely to perceive the effects of loss of crops and seed due to decreased rainfall, strong winds and droughts, hunger/food insecurity and loss of livelihoods due to increased temperature, human sickness due to increased pests and diseases, and are significant. These results suggest that farm household heads that are climate change aware are more likely to be less susceptible to the effects of the changing climate owing to their awareness, may embark into remedial measures to respond or act in order that they reduce the effects of climate variability and change. These results are supported by the findings from across the participants' focus groups, which highlighted the following:

“The effects of climate change on crops, humans, and livestock are not the same among smallholder households. Our friends with more acreage of land are better placed in terms of access to animal feed (pasture/fodder) than those with little land who normally depend on customary dambo land for feeding their livestock. Again, those smallholders affiliated to associations/farmers clubs have access to information and sometimes resources to help deal with effects as a result of the changing climate. Further, larger households have diversified means of withstanding the effects of climate change i.e. some family members would migrate in search for better survival mechanisms while others could go for on or off-farm activities for their livelihoods and in turn help the entire household. Finally, the

literate smallholders, would normally be aware of climate change and its effects well in advance due to their access to information through different media platforms, and prepare”

Furthermore, the results show that farm households in Chikwawa district (Dedza as reference category) are more likely to perceive the effects of falling of cultivated crops, hunger, food insecurity and loss of livelihoods, and lack of fodder and livestock deaths due to strong winds and droughts/dry spells. The tenth and eleventh rows of Table 3.11 show that, relatively, farm households in Nsanje and Zomba are more likely to perceive hunger, food insecurity and loss of livelihoods, and loss of crops and seed, drying pasture, lack of fodder and livestock deaths, human sickness deaths and low livestock production, poor crop yields, and falling of cultivated crops due to decreased rainfall, increased temperature, increased incidences of pests and diseases, and other factors, i.e., strong winds and drought/dry spells, and are significant. Generally, across the study districts, the results suggest that an increase in the population of the farm households' increases their exposure to climate variability and change effects. This is conceivable because increased population increases competition for resources which, when not controlled, results in depletion that may accelerate the effects of changing climate. The results from FGDs indicate that human sickness, strong winds, drought/dry spells are perceived to greatly affect crops, humans, and livestock. During the discussions, unopposed by other group participants, one of the participants in MFGDs and MxFGDs stated:

“Recently our community has been hit by diseases such that a reasonable proportion of people in the community were sick, this affected our daily activities including farming as the labour force was down due to illness, as that was not enough strong winds came and blew off our crops and including property, life hasn't been easy in this era of climate change. We have suffered reduced household seed bank as we cannot afford to buy improved seed in preparation for the next growing season, and finally this was the time we were heavily affected with droughts the previous year which was a total disaster resulting in reduced water sources for daily household chores, no pastures for livestock, hence, we had to walk long distances to fetch water and in search for pastures”.

Table 4. 16: Marginal effects of the variables in the ordered logit model for perceived effects of climate change on crops, humans, and livestock

Models	(1)	(2)	(3)	(4)	(5)	(6)
	Decreased rainfall		Increased temperature			
Variable	Hunger, food insecurity and loss of livelihoods	Loss of crops and seed	Lack of fodder and livestock deaths	Hunger, food insecurity and loss of livelihoods	Drying pasture, lack of fodder and livestock deaths	Loss of crop, and seed
Age of household head	-0.00(0.02)	0.00(0.02)	0.00(0.02)	0.00(0.02)	0.00(0.02)	-0.00(0.02)
Land holding size	-0.01(0.11)	-0.03(0.12)	-0.07(0.10)	-0.03(0.10)	-0.07(0.11) *	-0.02(0.12)
Group membership	-0.07(0.15) **	-0.11(0.16) ***	-0.25(0.14) ***	-0.12(0.14) **	-0.15(0.16) ***	-0.14(0.16) ***
Bean farming experience	0.00(0.02)	-0.00(0.02)	-0.01(0.02)	-0.01(0.02)	-0.00(0.02)	-0.00(0.02)
Family size	0.00(0.09)	-0.00(0.09)	0.01(0.08)	-0.06(0.08) **	-0.04(0.09) *	0.00(0.09)
Gender	0.01(0.47)	-0.07(0.49)	-0.01(0.42)	-0.02(0.45)	0.06(0.49)	-0.04(0.49)
Literacy	0.01(0.41)	0.07(0.43)	0.31(0.37) *	0.10(0.39)	0.03(0.42)	0.03(0.44)
Climate change awareness	0.27(0.65)	0.40(0.58) **	0.29(0.51)	0.44(0.53) *	0.31(0.57)	0.23(0.67)
Chikwawa	0.11(0.48)	0.05(0.53)	0.08(0.46)	0.23(0.44)	-0.03(0.52)	0.07(0.52)
Nsanje	0.15(0.47)	0.20(0.49) *	0.31(0.44)	0.36(0.41) **	0.30(0.48) **	0.25(0.46) **
Zomba	0.20(0.45) *	0.25(0.48) *	0.28(0.44)	0.44(0.39) ***	0.30(0.47) **	0.22(0.45) *
Classification accuracy (correctly predicted)	63.10%	62.50%	55.80%	60.90%	60.90%	64.00%
Log-likelihood	-238.41	-241.02	-328.31	-296.40	-270.01	-225.92
LR Chi ²	(11) = 57.26	(11) = 70.98	(11) = 92.18	(11) = 88.61	(11) = 95.98	(11) = 82.51
Pseudo R ²	0.149	0.184	0.170	0.179	0.200	0.186

Table 4.16 (con'd) Marginal effects of ordered logit model for perceived effects of climate change on crops, humans, and livestock

Models	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Variables	Increased incidences of pests and diseases			Others (Strong winds & droughts)			
	Human sickness	Deaths and low livestock production	Poor yields and loss of crops	Falling of cultivated crops	Hunger, food insecurity, and loss of livelihoods	Lack of fodder and livestock deaths	Loss of crop and seed
Age of household head	-0.00(0.02)	0.00(0.02)	0.00(0.02)	-0.00(0.02)	0.00(0.02)	0.00(0.02)	0.00(0.02)
Land holding size	-0.02(0.12)	-0.06(0.10)	-0.03(0.12)	-0.06(0.10)	-0.01(0.11)	-0.01(0.11)	0.00(0.12)
Group membership	-0.14(0.16) ***	-0.20(0.14) ***	-0.13(0.17) ***	-0.25(0.14) ***	-0.13(0.15) ***	-0.13(0.15) ***	-0.12(0.17) ***
Bean farming experience	-0.00(0.02)	-0.00(0.02)	-0.00(0.02)	-0.01(0.02)	-0.00(0.02)	-0.00(0.02)	-0.00(0.02)
Family size	0.00(0.09)	0.01(0.08)	-0.01(0.10)	0.02(0.08)	0.01(0.09)	0.01(0.09)	0.00(0.10)
Gender	-0.04(0.49)	-0.11(0.43)	0.07(0.54)	-0.22(0.43)	-0.05(0.46)	-0.05(0.46)	-0.06(0.50)
Literacy	0.03(0.44)	0.22(0.39)	0.01(0.46)	0.36(0.36) *	0.08(0.42)	0.08(0.42)	0.04(0.45)
Climate change awareness	0.23(0.67) **	0.31(0.54)	0.20(0.68)	0.26(0.53)	0.31(0.57)	0.31(0.57)	0.30(0.66) *
Chikwawa	0.07(0.52)	0.20(0.44)	-0.06(0.58)	0.36(0.45) *	0.26(0.45) *	0.26(0.45) *	0.05(0.53)
Nsanje	0.25(0.46) *	0.39(0.41) **	0.13(0.54)	0.33(0.44) *	0.21(0.46)	0.21(0.46)	0.21(0.47) *
Zomba	0.22(0.45) **	0.37(0.42) **	0.24(0.50) **	0.36(0.44) *	0.29(0.43) **	0.29(0.43) **	0.24(0.45) **
Classification accuracy (correctly predicted)	66.20%	61.20%	61.80%	56.50%	62.50%	62.50%	67.50%
Log-likelihood	-202.94	-304.79	-215.00	-333.90	-266.94	-266.94	-209.82
LR Chi ²	(11) = 76.72	(11) = 85.32	(11) = 80.73	(11) = 103.52	(11) = 77.57	(11) = 77.57	(11) = 77.16
Pseudo R ²	0.212	0.172	0.200	0.182	0.176	0.176	0.212

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significance $p < 0.0001$, ** $p < 0.01$, and * $p < 0.05$

Dedza district as the reference category

4.5.2.6 Household level general gendered perceptions of climate variability and change

Table 4.17 presents the marginal effects of ordered logistic regression models of gendered perceptions of climate variability. The dependent variables are constructed based on the general statements on gender issues related to climate variability and change. These climate change gendered issues which have a potential to improve households' food security (Refer to questions 4.5a to 4.5l of the survey questionnaire in appendix 1) include but not necessarily in that order:

- a) The same response between men and women to climate change.
- b) Adaptation strategies that are user friendly to both men and women.
- c) Men and women making adaptation strategy choices jointly at household level.
- d) Men and women having equal chances to exercise knowledge to deal with climate change.
- e) The same assistance between men and women in times of climate induced shocks/stresses.
- f) Equal destruction of natural resources between men and women,
- g) Women's non-involvement in choosing climate change adaptation resulting in low yields.
- h) Women's suggestions in tackling climate change that are not taken on board at household level.
- i) Women's innovativeness in dealing with climate change is not valued at household level.
- j) Potential of women's inclusion in production decision-making in improving household's food security.

Looking at the second row, models 3, 4, 6 and 7 of Table 4.17, for every extra acre of land holding size, the expected perceived joint choices of adaptation strategy between men and women, equal chances between men and women to exercise knowledge to deal with climate change, and equal destruction of natural resources between men and women are less likely and are significant. While the expected perceived women's non-involvement in choosing the right adaptation strategies resulting into low crop yields is more likely and is significant. These results suggest a negative relationship between farm households land holding size increases, and joint choices of adaptation strategy to climate variability and change, equal opportunities to exercise knowledge to deal with climate change, equal destruction of the natural resources

between men and women, and a positive relationship on non-involvement of women in choosing climate change adaptation strategies. From respondents general gendered perceptions of climate change related affirmations, joint adaptation strategies, equal destruction of natural resources between men and women, and women's non-involvement in production decision-making are statistically insignificant. However, equal chances to exercise knowledge to deal with climate change between men and women is statistically significant. This suggests that a clear majority of males perceive that both men and women have equal chances to exercise knowledge to deal with climate change. While female respondents express the divergence and affirms that there are no equal chances between men and women in exercising knowledge to deal with climate variability and change. These results are supported by the findings from the FFGDs that highlighted as follows:

“Within the farm households, when the acreage of land is larger, the gap between males and females gets larger in terms of how choices of adaptation strategies to deal with climate change, and use/destruction of natural resources are made. More often males are at the pole of choice making, and destruction of natural resources. Because of their monopoly in choices of adaptation strategies and use/destruction of natural resources, we (females) indirectly distance ourselves from most of the activities taking place leaving males to make choices/decision leaving our so ideas which could contribute to improved production in limbo, and hence the household sink into food self- insufficiency and insecure.”

Considering farm household group membership, for an additional farm household head group membership the expected perceived equal chances between men and women to exercise knowledge to deal with climate change is less likely while the expected perceived low yields due to non-involvement of women in choosing the right adaptation strategies to climate change are more likely and significant. This result suggests that there is a negative relationship between the household heads' affiliations to groups/associations and equal chances to exercise knowledge between men and women to deal with climate change. This is conceivable because household heads, especially in patriarchal society normally take full control of what is happening in farm households. This leaves women, who more often than not are household wives, without a say in dealing with climate change and thereby missing out on the ideas and knowledge which could contribute to improved crop yields.

With regard to bean farming experience, for every additional year of bean farming experience the expected perceived user friendliness of adaptation strategies between men and women, equal destruction of natural resources between men and women, and expected perceived potential of household food security due to women's inclusion in production decision-making are less likely and significant. These results suggest that farming experience of the household head negatively affects the user friendliness of adaptation strategies, the equal destruction or use of natural resources between men and women, and also food security at household level due to non-inclusion of women in production decision-making. This is plausible, probably because experienced farm household heads believe they have acquired enough knowledge and information over time and that they have all it takes to make production decisions, yet negatively affecting equally important entities in contributing to improved production in the face of climate change.

Regarding gender, male heads of households are more likely to perceive joint choices of adaptation strategies between men and women and is significant. This result suggests that in male-headed farm households, inclusion in decision-making is promoted. This is conceivable because in patriarchal society, despite women being household heads, they still give the spouse the chance to make or help make various decisions, including that of choice of adaptation strategies.

Referring to literacy level, literate farm household heads are more likely to perceive equal responses to climate change, joint choices of adaptation strategies, and equal chances to exercise knowledge to deal with climate change between men and women and are significant. These results suggest that literate farm household heads support equality between men and women in responding to climate change, joint choices of adaptation strategies and exercising knowledge to deal with climate change. This is plausible because literate household heads have access to information related to many issues around climate change that concern men and women, most of which are made available in print media.

For climate change awareness, climate change aware farm household heads are less likely expected to ignore women's suggestions on tackling climate change at household level and is significant. This result suggests that the more aware the household heads are, the more they will take on board women's suggestions in tackling climate change. By inference, such household heads are open to information sharing and ready to improve systems. The results on

literacy and climate change awareness are supported by focus group discussion findings (MFGDs, FFGDs and MxFGDs) highlighted as follows:

“Our fellow smallholders that are literate and aware of the changing climate, are quick to understand the importance of joint choices and suggestions in tackling climate change because they value joint choices encourage ownership, participation and taking responsibility of what is going on at farm household level.”

Looking at the study districts, farm households in Chikwawa district (Dedza as a reference category) are more likely expected to perceive low crop yields as a result of non-involvement of women in choosing the right adaptation strategy to climate change, non-valuing of women's innovativeness in dealing with climate change at household level, and women's inclusion in production decision-making has a potential to improve households' food security. Whilst farm households in Nsanje district are less likely expected to perceive non-involvement of women in choosing climate change adaptation strategy results in low crop yields, and women's suggestion on tackling climate change are not taken on board at household level. These results imply that in Chikwawa, low yields are attributable to non-involvement of women in choosing right adaptation strategies to climate change and believe in non-valuing women's innovativeness in dealing with climate change, and that women's inclusion in production decision-making has the potential to improve household food security. By contrast, farm households in Nsanje district (tenth row, and models 7 and 8 in Table 3.12) believe women's non-involvement in choosing climate change adaptation strategies do not result in low crop yields.

Table 4. 17: Marginal effects of ordered logistic regression models of gendered general perceptions of climate variability and change

Models	(1)	(2)	(3)	(4)	(5)
Variables	Marginal effects($dE(y)/dx$)				
	Men and women respond the same to climate change	Adaptation strategies are user friendly to both men and women	Men and women make adaptation strategy choices jointly at household level	Men and women have equal chances to exercise knowledge to deal with climate change	Same assistance between women and men in times of climate induced shocks/stresses
Age of household head	0.01(0.01)	0.01(0.01)	0.01(0.01)	0.00(0.01)	0.01(0.01)
Land holding size	-0.08(0.06)	-0.05(0.06)	-0.07(0.08) *	-0.07(0.08) *	-0.06(0.07)
Group membership	-0.05(0.09)	0.10(0.08)	0.00(0.10)	-0.08(0.11) *	-0.06(0.09)
Bean farming experience	-0.01(0.01)	-0.02(0.01) **	-0.01(0.01)	-0.00(0.02)	-0.01(0.01)
Family size	-0.07(0.05)	-0.04(0.05)	-0.02(0.06)	-0.01(0.07)	-0.00(0.06)
Gender	0.06(0.27)	-0.03(0.26)	0.32(0.26) *	0.20(0.31)	-0.11(0.33)
Literacy	0.55(0.23) **	0.19(0.22)	0.25(0.23) *	0.28(0.26) **	0.11(0.26)
Climate change awareness	-0.03(0.38)	-0.31(0.43)	-0.04(0.44)	0.08(0.45)	0.08(0.39)
Chikwawa	0.24(0.32)	-0.09(0.28)	0.15(0.39)	0.01(0.40)	-0.13(0.33)
Nsanje	0.43(0.34)	0.14(0.30)	0.10(0.36)	0.20(0.44)	0.08(0.36)
Zomba	0.11(0.31)	0.05(0.28)	0.02(0.35)	0.20(0.45)	0.33(0.38)
Classification accuracy (correctly predicted)	41.00 %	48.60 %	59.00 %	62.10 %	49.50 %
Log-likelihood	-422.71	-400.30	-332.00	-310.10	-391.11
LR Chi ²	(11) = 78.07	(11) = 82.03	(11) = 94.30	(11) = 92.95	(11) = 78.71
Pseudo R ²	0.134	0.143	0.162	0.151	

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significance $p < 0.0001$, ** $p < 0.01$, and * $p < 0.05$

Dedza reference district category

Table 4.17 (cont'd). Marginal effects of ordered logistic regression models of gendered general perceptions of climate variability and change

Models	(6)	(7)	(8)	(9)	(10)
Variables	Marginal effects ($dE(y)/dx$)				
	Equal destruction of natural resources between men and women	Women non-involvement in choosing climate change adaptation results in low crop yields.	Women's suggestion on tackling climate change are not taken on board at household level	Women's innovativeness in dealing with climate change is not valued at household level	Women's inclusion in production decision-making has a potential to improve households' food security
Age of household head	0.01(0.01)	-0.00(0.01)	-0.00(0.01)	-0.01(0.01)	0.01(0.02)
Land holding size	-0.16(0.07) **	0.14(0.07) **	0.03(0.06)	0.04(0.06)	-0.03(0.10)
Group membership	-0.02(0.09)	0.25(0.09) ***	-0.05(0.08)	0.04(0.08)	0.05(0.13)
Bean farming experience	-0.03(0.01) **	-0.00(0.01)	-0.01(0.01)	-0.01(0.01)	-0.02(0.02) *
Family size	-0.06(0.05)	0.05(0.05)	0.02(0.05)	0.05(0.05)	0.01(0.08)
Gender	0.14(0.27)	-0.04(0.26)	-0.25(0.27)	-0.32(0.28)	-0.06(0.42)
Literacy	0.25(0.23)	-0.32(0.26)	-0.30(0.24)	-0.20(0.23)	0.07(0.35)
Climate change awareness	-0.10(0.39)	-0.27(0.43)	-0.60(0.46) *	-0.44(0.45)	-0.06(0.59)
Chikwawa	-0.06(0.30)	0.75(0.40) ***	0.37(0.31)	0.49(0.34) *	0.28(0.48) *
Nsanje	0.19(0.32)	-0.62(0.27) **	-0.53(0.27) *	-0.34(0.27)	-0.04(0.44)
Zomba	0.17(0.32)	-0.14(0.27)	-0.25(0.27)	0.08(0.28)	0.17(0.46)
Classification accuracy (correctly predicted)	33.80 %	44.2 %	40.70 %	47.00%	50.80 %
Log-likelihood	-421.37	-408.87	-404.51	-396.53	-334.77
LR Chi ²	(11) = 60.40	(11) = 121.57	(11) = 106.16	(11) = 98.97	(11) = 74.79
Pseudo R ²	0.147	0.176	0.153	0.158	0.152

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significance $p < 0.0001$, ** $p < 0.01$, and * $p < 0.05$

Dedza district as the reference category

4.6 Chapter summary

This chapter aims to understand farmers' perceptions, knowledge and impacts of climate variability and change in smallholder farming. To achieve this, the study employs the following research questions: i) How do farmers' perceptions of climate variability and change, and compare with meteorological data, ii) How are smallholder farmers affected by the impacts of climate variability and change, iii) How are decisions on the use of adaptation strategies made in smallholder farming, iv) Are men and women affected, perceive, and respond the same to the varying and changing climate.

The results indicate no statistical significant differences in terms of perceptions of and responses to climate variability and change between males and females. However, the results indicate that males and females are perceived to be affected differently by different climate change shocks, however, some climatic shocks/stresses show no statistical significant differences in how they affect both males and females. The results also show that males are at the pole of decision-making than females on the use adaptation strategies to climate variability and change.

Econometric models are employed to estimate farmers' perceptions of rainfall and temperature characteristics, and their decision on the use of adaptation strategies using a binary logistic regression technique. The perceived future changes in climate, crop production, effects of climatic shocks and stresses, and gendered general perceptions of climate change are estimated using ordinal logistic regression technique. The results from binary logistic regression reveal that group membership, bean farming experience, family size, literacy levels of household heads, and climate change awareness have significant effects on rainfall characteristics, temperature, and crop production. Group membership influences perception of the amount of the main rainfall season positively, while bean farming experience negatively influences the perception of the ending of main rainfall season, and positively the amount of main rainfall season and crop production. Other results show that farm household size influences positively the perceptions of onset and ending of the main rainfall season. Literacy influences perception of onset of the main rainfall season negatively while climate change awareness influences perception of future changes in both rainfall and temperature negatively. These results highlight the importance of individual differences, motivations, organizational behaviours, past experience and external factors that add value and meaning to the surrounding in determining perceptions of climate variability and change.

Furthermore, group membership and bean farming experience have significant effects on the use of adaptation strategies to climate variability and change. Farm household group membership positively influences the decision on use of irrigation, and crop rotation, and negatively on chemical fertilizers and non-farm activities, while bean farming experience influences negatively the decision on use of drought tolerant varieties and changes in planting times, and positively influences the use of chemical fertilizers as adaptation strategies to climate variability and change. The results suggest that policies aimed at improving farmer groups and associations could improve on the use of climate change adaptation strategies through shared experiences and information.

The findings also reveal that group membership and literacy have significant effects on the perceptions of effects of climatic shocks/stresses on crop production (bean production). Group membership influences positively the expected perceived effect of pests and diseases, and heat wave, while literacy influences negatively the expected perceived effect of heat wave on crop production. Finally, the findings further reveal that land holding size, group membership, bean farming experience, literacy and gender have significant effects on gendered aspects of climate variability and change. These results highlight the importance of resource ownership, associations, knowledge and information in determining perceptions of the varying and the changing climate. The econometric model results suggest that group membership, farming experience, literacy, family size, and climate change awareness are important in explaining and shaping farmers' perceptions of the varying and changing climate. Based on those perceptions, farmers choose whether or not to use the adaptation strategies to climate change. Policies aimed at improving and encouraging farmer groups, literacy, and climate change awareness, and promoting gender inclusive farming activities among the smallholder farming communities appear to be important intervention areas that can affect perceptions and improve on use of appropriate adaptation strategies, thereby reducing the effects or impacts of the varying and changing climate. Having acknowledged the farmers' perceptions of climate variability and change, the next chapter presents the empirical results and discussions on smallholder farmers' decision-making and direct involvement in performing bean production activities at farm household level in the face of climate variability and change.

CHAPTER 5. DECISION-MAKING AND DIRECT INVOLVEMENT IN COMMON BEAN PRODUCTION ACTIVITIES IN SMALLHOLDER FARMING IN THE FACE OF CLIMATE VARIABILITY AND CHANGE

5.1 Introduction

The chapter aims to address Objective 2 of the study which explores factors affecting smallholder farmers' decision-making and their direct involvement in performing bean production activities at farm household level in the face of climate variability and change. Regarding the structure of the chapter, Section 5.2 presents analytical framework and definition of variables. Presentation and discussion of empirical findings follow in Section 5.3. Finally, Section 5.4 provides a summary of the chapter while the conclusions and recommendations are part of Chapter 7.

5.2 Analytical framework and definition of variables

This section highlights a structure, or a model, designed to help explain how the analysis of farmers' participation and direct involvement in performing bean farming activities will be conducted.

5.2.1 Analytical framework

This analytical framework is built on the study's conceptual framework which acknowledges that the farmers' perceptions of climate variability and change influence their participation in decision-making and direct involvement in performing production activities in smallholder farming. It also acknowledges that the decisions on farming activities are made in a way that the farming system survive the disturbances at a result of climate variability and change. These activities are planned to help the smallholder farmer survive the effects of the varying and changing climate. The main domain for resource allocation, and investment, marketing, production and conservation decisions in the smallholder farming systems, particularly in the sub-Saharan Africa, centres on the farm household. At farm level, these decisions are affected and influenced by a number of factors which include, but not limited to, the following: farm management factors, i.e., choice of agricultural enterprises, allocation of labour, land, capital and inputs, and marketing; social economic factors, i.e., assets, household members, cultural or individual attributes, risk tolerance, debts and obligations, and off-farm employment and income; biophysical factors, i.e., moisture, soil, slope, altitude; and biological factors. Many critical farming decisions are made at household level and serve as the rudimentary unit of production (deSherbinin *et al.*, 2008). In many farming household research, unitary and

collective models have been used to understand the household decision-making, however unitary model emphasizes on household representing others' opinions thereby creating divergence in preferences and power asymmetries (deSherbinin *et al.*, 2008; van Koppen & Hussain, 2007). Again, a collective model has become more popular in literature Bjornlund *et al.* (2019); this assumes that decision-making takes place between two separate individuals, commonly a husband and a wife, but also involves other household members. This approach allows for consideration of both cooperative and non-cooperative bargaining, which together offer several beneficial characterizations of intra-household decision-making. Independent action by spouses may or may not be Pareto efficient, where individuals have different preferences and bargaining power. Those with more bargaining power will have more control over assets and decision-making which may change over time (Anderson *et al.*, 2017; Doss & Meinzen-dick, 2015). The collective model categorises the farm households' decision-making into four groups or systems namely; male-managed, female managed, separately managed, and jointly managed; the latter being less popular in SSA compared to Asia and Latin America (Meinzen-Dick *et al.*, 2012). UN Women (2013) assert that jointly managed systems are becoming popular in the literature and commonly used as an indicator of gender equality as working collectively, the combined strengths of different entities can be mobilized to generate improved efficiencies and synergies, leading to greater effectiveness and enhanced development results. Hence, joint ownership of an asset or a decision implies less likelihood of gender inequality. Further, jointly agreed positions are complicated to attain, as it involves discussions to reach a consensus and sometimes can represent conflict as well as cooperation (Njuki *et al.*, 2014). Despite collective model's popularity and rationality, a mixture of decision-making models is still being used to greater extent depending on the household characteristics, such that collective is more likely in large households; unitary and non-cooperative models are more likely in female-headed households; collective and joint models are more likely where household heads are older; and bargaining is more cooperative where household heads are more educated. This variation in decision-making models potentially also applies in rural settings (Booyesen *et al.*, 2013). Usually, contribution to farm household level decision-making is tested by 'who' makes a specific decision on particular production activities. Such kind of examination is captured through survey questions surrounding who in the household makes decisions, and is believed to capture bargaining power and how involved and influential household members are in decision-making (Doss, 2013). Different household members, even those who may not be present on-farm, frequently take decisions. In Demographic Household Surveys (DHS) and The Living Standards Measurement Study

Integrated Surveys on Agriculture (LSMS-ISA) farm household decision-making responses were categorized into decisions taken alone by the woman or a man; and by woman and man jointly (with her/his spouse), and other, i.e., spouse and other household members, hired labour etc. (Leigh *et al.*, 2017; Twyman & Deere, 2015). Essentially, drawing from more than one methodology provides a better understanding of the integrated nature of household decision-making. This study, therefore, uses the decision-making approaches of multiple household members to acknowledge the diversity of households in decision-making (Mcgregor *et al.*, 2001). This analytical framework is built on a premise that farm household decisions are made by different members of the household and that their decision-making position has a bearing on the overall control of resources. The dominance in the decision-making process on farm production activities breeds less empowerment within the household and leaves participation and involvement in the activities by other household members at stake.

5.2.2 Estimation technique

This chapter uses the logit model to estimate farmers' participation in decision-making on common bean production activities, and direct involvement in performing common bean production activities in the face of climate variability and change. The activities modelled include site selection, land or bush clearing, ridging or ploughing, planting, fertilizer application, spray against pests and diseases, harvesting, transporting beans from the garden, threshing, winnowing, sorting, and post-harvest storage. Details of the estimation process are presented in chapter four Section 4.2, Subsection 4.2.2, and Sub-subsection 4.2.2.1.

5.2.3 Definition of variables

5.2.3.1 Dependent variables (DVs)

The dependent variables are constructed in folds around the farm households' common bean production activities. Firstly, the dependent variables are constructed based on whether or not the farm households' heads participated in decision-making on bean production activities. Secondly, whether or not the farm households' heads directly engage in performing the activities. This gives a dichotomous dependent variable coded as: 1 if participated in decision-making on bean production activity, and 0 otherwise for the former and 1 if direct involvement in bean production activities, and 0 otherwise for the later. Therefore, the normal common bean production activities which include, but not limited to, site selection, land or bush clearing, ridging or ploughing, planting, fertilizer application, spray against pests and diseases, harvesting, transporting beans from the garden, threshing, winnowing, sorting and post-harvest storage, are dichotomized to form binary dependent variables based on whether or not

the farm household heads participate in decision-making and/or directly engage into bean production activities. At farm household level, decisions on production activities can be made by household members or others depending on the activities. This study has postulated that farm household level decision-making on bean production activities is normally made by, but not limited to; household head (either male or female head), spouse, joint decision between the household head and spouse, spouse and other household members, household head and other household members, and others (i.e., hired labour, etc.). A series of questions are constructed to capture decision-making on production activities, and involvement in performing activities at farm level. These questions include: do you (household head/ spouse) participate in decision-making on bean farming activities, and do you directly engage, or involve yourself in, performing bean farming activities?

5.2.3.2 Independent variables (IVs)

There are a range of socio-economic factors that influence decision-making at farm household level, including age, household size, landholding size, common bean growing experience, group membership, gender, awareness of climate variability and change, literacy, and districts fixed effects (Doss & Njuki, 2014; Doss & Meinzen-Dick, 2015; Mutenje *et al.*, 2016). This study has adopted these IVs to explain the expected change in DVs as a result of a unit change in IVs. The details of these independent variables are presented in Chapter 4, Section 4.4 in Table 4.1.

5.3 Empirical results and discussions

This section presents empirical results and discusses frequencies of how decisions on bean farming activities are made and further discusses farm households' direct involvement in bean farming activities. The remainder of the section discusses the binary logistic regressions on households' participation in decision-making on, and direct involvement in, bean farming activities in smallholder farming.

5.3.1 Participation in decision-making on common bean production activities in smallholder farming in the face of climate variability and change.

5.3.1.1 Site selection

Table 5.1 presents the frequencies of farm household decision makers on bean farming activities. The bean farming households have been disintegrated into female and male-headed households. Looking at the first row of [Table 5.1](#), in female-headed household results indicate approximately 87 percent of decisions on site selection are made by household heads. This result suggests a clear dominance in decision-making of household heads and low spousal participation in female-headed households. By contrast, in male-headed households' 54 percent of decisions on site selection are made by household heads, with 28 percent made by spouses, and 17 percent joint decisions. This result suggests there is more inclusion and delegation of responsibilities in male-headed household than female-headed households. Overall, decisions on site selection are made by 62 percent of the heads, with 24 percent by spouses, and 14 percent joint decision across household headships. This result is conceivable though the dynamics are changing. Taking the notion that common bean has been regarded as a feminine crop, it is not surprising to have a lower percentage of spousal decision-making on site selection in female-headed households, and a higher percentage of spousal decision-making in male-headed households. The lower percentages in female-headed households regarding site selection through spouse and joint decisions can also be attributed to the fact that most female-headed households do not have spouses. With reference to the first row of Table 5.2, 65 percent of the female respondents, and 96 percent of the male respondents participated in decision-making on site selection and are significant. This result implies that a clear majority of the male respondents were involved in decision-making on site selection. This could be attributed to the fact that males normally own resources such as land and therefore have powers to decide on the land use. This finding is supported by the results from the discussions from MFGDs, FFGDs, and MxFGDs as follows;

“In most cases except where the household is headed by the female head, issues associated with land including land use are controlled by males (FFGDs). We normally want to engage females in site selection for crop production including common bean, but when given that chance they misplace where to grow which crops based on land history, as such we just do it on our own (MFGDs). As long as males are available in the farm household, decision on site selection is done by them unless delegated because they are mostly land owners (MxFGDs)”.

5.3.1.2 Land/bush clearing

Referring to female-headed households in the second row of Table 5.1, approximately 84 percent of decisions on land/bush clearing are made by household heads. Further, approximately 12 percent of the decisions on land/ bush clearing are made by spouses. While in male-headed households, about 52 percent of the decisions on land/bush clearing are made by household heads, and 27 percent are made by spouses. In general, 60 percent of the household heads make decisions on land/bush clearing. With respect to male and female participation in decision-making, the second row of Table 5.2, the results show approximately 64 percent of the female respondents, and 99 percent of the male respondents participated in decision-making on land/bush clearing and are significant. The result suggests higher males' participation in decision-making on land/bush clearing than females. This could be attributed to nature of the activities which most of the females may not be willing to take part. The result from the focus group discussions is in support of this finding. The discussants from MFGDs, FFGDs, and MxFGDs explained as follows;

“We leave the males decide on when to do land/bush clearing because they are the ones who normally draw a plan of the growing calendar/ season. However, where the household is headed by females, such a decision is made by females (FFGDs). Depending on businesses in the farm households, decisions on land/bush clearing are either made by males or females, for example in times when our husbands have gone out to look for seasonal jobs and the signs of season readiness are showing, where site selection has already been done, females step up to decide on bush clearing (MxFGDs). When we are not engaged with other equally important on-farm or off-farm activities, decisions on land/bush clearing are made by us (MFGDs)”.

Table 5. 1: Two-way table of frequencies of participation in decision-making on common bean production activities at household level

Decisions	Decision makers on bean farming activities at farm household level (% in brackets)					
	Self/Household head	Spouse	Self & spouse jointly	Self & other HH members	Spouse & other HH members	Others
<i>Female-headed household</i>						
Site selection	72(87)	10(12)	1(1)	0(0)	0(0)	0(0)
Land/bush clearing	70(84)	10(12)	1(1)	1(1)	1(1)	0(0)
Ridging/ploughing	70(84)	9(11)	3(4)	1(1)	0(0)	0(0)
Planting	70(84)	8(10)	1(1)	2(2)	1(1)	1(1)
Fertilizer application	48(58)	3(4)	1(1)	2(2)	1(1)	28(34)
Pest and disease sprays	52(63)	6(7)	1(1)	1(1)	1(1)	22(27)
Harvesting time	69(83)	9(11)	1(1)	2(2)	1(1)	1(1)
Transportation	69(83)	8(10)	2(2)	3(4)	1(1)	0(0)
Threshing	71(85)	9(11)	1(1)	1(1)	1(1)	0(0)
Winnowing	72(87)	9(11)	1(1)	0(0)	1(1)	0(0)
Sorting	70(84)	9(11)	1(1)	2(2)	1(1)	0(0)
Storage	73(88)	8(10)	1(1)	0(0)	1(1)	0(0)
<i>Male-headed household</i>						
Site selection	147(54)	77(28)	47(17)	1(0)	0(0)	1(0)
Land/bush clearing	143(52)	74(27)	55(20)	1(0)	0(0)	0(0)
Ridging/ploughing	135(50)	73(27)	58(21)	5(1)	2(0.7)	0(0)
Planting	135(50)	67(25)	66(24)	3(1)	2(1)	0(0)
Fertilizer application	76(29)	41(15)	30(11)	5(2)	0(0)	121(44)
Pest and disease sprays	122(45)	55(20)	27(10)	1(0)	0(0)	68(25)
Harvesting time	140(51)	65(24)	61(22)	6(2)	1(0)	0(0)
Transportation	137(50)	64(23)	63(23)	5(2)	4(2)	0(0)
Threshing	153(56)	73(27)	10(15)	5(2)	2(1)	0(0)
Winnowing	150(55)	102(37)	8(3)	3(1)	9(3)	1(0)
Sorting	136(50)	72(26)	52(19)	7(3)	6(2)	0(0)
Storage	144(53)	71(26)	54(20)	0(0)	1(1)	3(1)
<i>Decision-making across male and female-headed household</i>						
Site selection	219(62)	87(24)	48(14)	1(0)	0(0)	1(0)
Land/bush clearing	213(60)	84(24)	56(16)	2(1)	1(0)	0(0)
Ridging/ploughing	205(58)	82(23)	61(17)	6(2)	2(1)	0(0)
Planting	205(58)	75(21)	67(19)	5(1)	3(1)	1(0.3)
Fertilizer application	124(35)	44(12)	31(9)	7(2)	1(0)	149(42)
Pest and disease sprays	174(49)	61(17)	28(8)	2(2)	1(0)	90(25)
Harvesting time	209(59)	74(21)	62(17)	8(2)	2(1)	1(0)
Transportation	206(58)	72(20)	65(18)	8(2)	5(1)	0(0)
Threshing	224(63)	82(23)	41(11)	6(2)	3(1)	0(0)
Winnowing	222(62)	111(31)	9(3)	3(0)	10(3)	1(0)
Sorting	206(58)	81(23)	53(15)	9(3)	7(2)	0(0)
Storage	217(61)	79(22)	55(15)	0(0)	2(1)	3(1)
<i>Decisions and decision units</i>						
Overall	202(57)	78(22)	48(14)	5(1)	3(1)	21(6)

Note: $n=356$ and Percentages in parenthesis

5.3.1.3 Ridging/ploughing

Considering decisions on ridging or ploughing, the results indicate that in female-headed households, approximately 84 percent of decisions are made by household heads, while in male-headed households about 50 percent are made by household heads. Overall, 58 percent of the decisions on ridging/ploughing are made by household heads, with 23 percent spousal decisions, and 17 percent joint decisions. This result suggests that there is higher self-decision-making power in female-headed households than in male-headed households. The result further suggests that there is more inclusion in such decision-making in male-headed households than in female-headed households. In terms of male and female participation in such decisions, the results in the third row of Table 5.2 indicate approximately 99 percent male, and 65 percent female participation and are significant. By this, it is clear that participation in decision-making on ridging /ploughing is dominated by males. Such dominance of decision-making by males could be as a result of power dynamics at farm household level. The findings from the focus group discussions with male, female and mixed groups (MFGDs, FFGDs and MxFGDs), the discussants explained as follows;

“Mostly, timing of most of the farming activities at household level are decided by males, particularly ridging/ploughing is planned in line with the anticipation of rainfall onset which males are mostly acquainted to (FFGDs). It is our responsibility as household heads to make sure that decisions on key farming activities are made by us in order that preparation of the season is done timely and appropriately (MFGDs). Joint decisions are also made between males and females within the household largely where division of labour is not common. Where division of labour is common females and males make decision on their own depending on activity allocation (MxFGDs)”.

5.3.1.4 Planting

Results indicate approximately 84 percent of decisions on planting in female-headed households are made by household heads with only 10 percent made by spouses. By contrast, 50 percent of planting decisions are made by household heads in male-headed households, while 25 percent are made by spouses. Further, in male-headed households, 24 percent of decisions (both household heads and spouses) on planting are made jointly (household head and spouse). Generally, notable decisions on planting in farm households are made by 58 percent of the household heads, 21 percent spouses, 16 percent jointly. The results suggest that household heads in female-headed households are on top in making decisions on planting

compared to household heads in male-headed households. Again, spousal and joint decisions are highly recorded in male-headed households compared to female-headed households possibly because women in the households are more associated with common bean farming and know that the planting exercise is so critical, requiring well-informed decisions, hence, attracting joint decisions. The result for male and female participation in decision making on planting indicates that 99 percent of males, and 67 percent of females participate in decision-making (fourth row of Table 5.2). This result implies that males participated more than females in decision-making regarding planting of common beans. Planting is the process that involves placing/putting seeds, seedlings or young plants in the soil/ground to grow. This process involves a solid knowledge of local conditions and plant preferences. By definition of a smallholder farmer in Malawi, farmers often have a very small growing land, thus, necessitating strategic planting schedules and care of crops to maximize harvest throughout the year. Results from the focus group discussions support this finding as follows;

In rain-fed production, decision of planting time is very crucial as it relates to understanding the right soil moisture content that will normally attract planting exercise. For this reason, males are at the pole of making planting decisions due to their access to information through trainings on different farming activities as they participate in different groupings working on agricultural activities (FFGDs). Many females normally do not participate in most of the groupings discussing farming activities and therefore miss out on some of the information, as such males normally are on top of information access and hence dominate decision making (MFGDs).

5.3.1.5 Fertilizer application

Referring to decision-making on fertilizer application, in female-headed households, 58 percent of the decisions are made by household heads, while 34 percent are made by others. By contrast, in male-headed households (fifth row), 29 percent are made by household heads, 15 percent by spouses and 44 percent by others. Overall, the results suggest 35 percent of the decision on fertilizer application are made by household heads, 12 percent by spouses, 9 percent jointly, and 42 percent others. The higher percentage of decision-making on fertilizer application by others implies that fertilizer application in common beans by smallholder farmers is not a common practice. Considering how males and females participate in decision making on fertilizer application, the results in the fifth row of Table 5.2, indicate statistical

insignificant differences. Across the focus groups (MFGDs-male focus group discussions, FFGDs-female focus group discussions, and MxFGDs-mixed focus group discussions):

“The discussants highlighted that fertilizer application is not our traditional practice of growing common beans. It is very uncommon in most of us to make a decision or plan to apply fertilizer to common beans, because we have a belief that we can harvest common bean without applying fertilizer. Hence, when you see smallholder farmers applying fertilizer to common bean just know that there must be someone external behind that. We have recently noticed that our common bean harvests are now dwindling. Hence, government extension workers and NGOs come to train us on the importance of use of fertilizers in common bean due to low soil fertility levels. It still remains a problem because it is only at an experimental stage where we are normally given small amounts of fertilizer to appreciate the difference. Once the NGOs stop supporting us everything ends there as you know fertilizer has become expensive that not many can afford”.

This quote gives an implication that the decision on fertilizer application to common beans in most of the smallholder farmers is influenced by external actors.

Common beans are among the legume crops which are able to acquire their nitrogen from soil and also from symbiotic nitrogen fixation (SNF) which provides an alternative source of available nitrogen (N) to the individual plant (Unkovich *et al.*, 2008). In common bean agriculture, around 60 percent of nitrogen (N) is derived from soil (Ndfs) with 40 percent supplied through SNF process (Peoples *et al.*, 2009; Unkovich & Pate, 2000). Improving SNF potential serves, not only as a low-cost strategy to maintain productivity, but also contributes to the possibility to successfully grow grain legume crops with minimal N fertilizers in soils with N deficiencies, thereby reducing both the cost of crop production and risk for hunger and malnutrition (Vance, 2001).

5.3.1.6 Pest /disease sprays

For decisions on pest and disease sprays, the results indicate, 63 percent of the decision on pests and disease sprays in female-headed households are made by household heads, and 27 percent by others. By contrast, 45 percent of such decisions are made by household heads, and 25 percent by others in male-headed households. Interestingly ‘others’ reported a higher percentage of decision-making, this is because this option included those who don’t apply

pesticides to their common bean, hence, had shown no orientation on the basis of decision-making. For the participation of males and females in decision making on pest /disease sprays, the results in the sixth row of Table 5.2, show participation of 84 percent males, and 43 percent females. This suggests that more males than females participate in decision-making on pests/diseases sprays. Among common bean production challenges, climate variability and change, pest and disease attack remain critical. As per the focus group discussions, the discussants explained as follows;

“The work of spraying against pest and diseases require expertise and basically the chemicals are known to be harmful to human as such we normally leave this to males to make decisions on when to apply. Again, lifting the sprayers at the back requires a lot of physical effort which is not normally provided by the females. However, with proper training, females do participate in making decision on this but relatively men dominate because of their high knowledge base in these and physically than females (FFGDs)”.

Nevertheless, the uppermost damage and yield losses on common bean production stems from pest and disease attack. So far, the most notable pest for beans is aphid which is serious during all development stages of plant growth, i.e., young leaves, flower buds, and young pods. Such damage causes retarded growth and premature flower abortion resulting into low yield (Mwanauta *et al.*, 2015). Controlling pests and diseases using pesticides to curb the yield losses is a rational idea though in most African countries, farmers tend to neglect because of the high cost of synthetic pesticides (Sola *et al.*, 2014).

5.3.1.7 Harvesting time

Looking at the decisions on harvesting time in female-headed households, results indicate that 83 percent of decisions on harvesting time are made by household heads, 11 percent by spouses. By contrast, in male-headed household 51 percent of such decisions are made by household heads, and 24 percent by spouses. In general, most of the decisions on harvesting time at farm household level are made by 59 percent of the household heads, 21 percent by spouses, and 17 percent jointly. This result suggests that most of the decisions about harvesting time are made by female heads at household level; this is supported by a large percentage of self-decisions in female-headed households and a remarkable proportion of spousal decisions in male-headed households. However, in terms of male and female participation in decision-making on harvesting time, the results in the seventh row of Table 5.2 show that 94 percent males, and 70 percent females participate. This suggests that despite a larger percentage of female

participation in decision-making on harvesting time in female-headed households, generally males are more likely than females to participate. The results from the focus group discussions are explained as follows in support of this finding;

Because males tend to take control over what's going on in a household, they are always in the forefront to decide on to when to harvest common bean. They normally do this because they at this time they are pretty aware that the production chain is narrowing down to the market where they will benefit in monetary term and they will make sure this well timely to avoid any losses which can translate in loss of revenue (FFGDs). Apart from farming household decision making, the females are directly involved in other family decision making which sometimes take them out of making decisions on crucial farming activities, as such we take total responsibility of farming activity decision while they engage into maternal household chores decisions (MFGDs). However, decisions on harvesting time can be made either by males or females depending on whether they are female/male headed (MxFGDs).

The inclusion aspect in decision-making on harvesting time is acknowledged by a reasonable percentage of joint decisions. Decisions on harvesting time for common bean is crucial because any delays may result in shattering, thus opening of the pods or the silique, which causes seeds to be released (Dong & Wang, 2015). Crop losses at harvest due to shattering can be substantial, especially in some traditional crops such as common beans with a history of hand harvest (Ogutcen *et al.*, 2018). However, is essential for the propagation of their offspring in wild plants despite being a major cause of yield loss in crops (Dong & Wang, 2015).

5.3.1.8 Transportation of harvested beans from the field

With reference to transportation of harvested common beans, results indicate that 83 percent of the decisions on transportation of the common bean produced from the field to the homes are made by the household heads, and 10 percent by spouses in female-headed households. However, 50 percent of such decisions are made by household heads, 23 percent by spouses, and joint in male-headed households. Overall, farm households' decisions on transportation of bean produce from fields to homes are made by 58 percent of household heads, 20 percent spouses, 18 percent jointly. The results suggest that most decisions on transportation of common bean produce/harvest from the field to the homes are made by heads in female-headed households with little division of power as indicated by lower percentage of spousal and joint decision-making. The results further suggest that there is more division of power in male-

headed households as indicated by a lower proportion of self-decisions, higher proportion of spousal and joint decisions on transportation of bean harvest from field to homes. Considering participation of males and females in decision-making on transportation of harvested beans from the fields to places where further processing is expected to take place, the results in the eighth row of Table 5.2, indicate that 95 percent males, and 70 percent females participate and are significant. This suggests that males are more likely than females to make decisions on harvest transportation. This could be attributed to the mode of transportation of the harvests, i.e., headload or oxcart would attract male decisions as such activities are culturally undertaken by males. This finding is supported by the results from the focus group discussions as follows;

Normally where the amount of our common bean harvests are high, decisions on produce transportation is handled over to males who are expected to explore different modes of transporting the produce. However, where the produce are low and that simple headload transportation can do, females are quick to make such decisions (FFGDs). At farm household level, revenue realized from crop produce is kept and controlled by the males as such where decisions on produce transport is associated with cash, males take charge (MxFGDs).

5.3.1.9 Threshing

For decision on threshing, about 85 percent of decisions on threshing of common beans in female-headed households are made by household heads, 11 percent spouses, and 1 percent jointly, as against 56 percent by heads, 27 percent spouses, and 15 jointly in male-headed households. In general, household heads contribute 63 percent on decisions made on threshing of common beans, 23 percent spouses, and 11 percent joint. The result, suggests more females than males participate in decisions on threshing common beans in female-headed households. Similarly, males are more likely than females to participate in decision-making on threshing. However, in term of disaggregating participation in decision-making by males and females, at farm household level, the results show statistical insignificance (ninth row of Table 5.2). Threshing is the act of removing the individual beans from the pod husk and requires a good bit of muscle. There are different ways in which common beans are threshed. In Malawi, most smallholder farmers thresh their beans using their hands or sticks.

5.3.1.10 Winnowing

Referring to decision-making on winnowing, in female-headed households, 87 percent of the decisions on winnowing are made by the heads, and 11 percent by spouses. While in male-headed households 55 percent by household heads, and 37 percent by spouses. Overall, notable decisions on winnowing are made by the household heads (62 percent), spouses (31 percent), and spouses and heads jointly (3 percent). Referring to the disaggregated male and female participation in decision-making on winnowing, the results in the tenth row of Table 5.2, indicate that 32 percent males and 83 percent of females participate and are significant. This result simply suggests that decisions on winnowing are dominated by women, coupled with the higher proportion of self-decisions in female-headed households, and remarkable spousal decisions in male-headed households. The focus group discussions support this finding in the following;

The manual hand operated equipment(a bamboo weaved shallow basket) used for winnowing is mostly used by females for different purposes, and in our cultural set up it looks awkward to see males using the equipment and that's why decisions on when to do the winnowing is dominantly done by females (MFGDs). Winnowing is associated with a lot concentration when undertaking it as it involves removing the chaff and also dust is associated with that and is a slow process, therefore men tend to shun away from it (FFGDs).

5.3.1.11 Sorting

With reference to decision-making on sorting, in female-headed households 84 percent of decisions are made by household heads, and 11 percent by spouses. On the other hand, household heads make 50 percent of the decisions on sorting, 26 percent by spouses and 19 percent joint. Generally, 58 percent of the decisions on sorting at farm household level are made by household heads, 23 percent by spouses, and 15 percent jointly. This suggests that decisions on sorting are usually made by women as indicated by the higher percentage of participation in decision-making by household heads in female-headed households coupled with a reasonable proportion of spousal and joint decision in male-headed households. However, disaggregating male and female participation in decision-making on sorting the results show statistical insignificance (eleventh row of Table 5.2). Sorting is usually done for different purposes. Some may be based on market requirements, others based on post-harvest storage requirements, and others for seed. In the smallholder farming system, most of these, if not all, are aimed at removing discoloured seed, thereby reducing the level of contamination

by certain seed-borne fungi and improving seed germination (Dube *et al.*, 2014). However, in other applications sorting is done to achieve uniformity in terms of grain sizes.

5.3.1.12 Storage

With regards to decision-making on storage, 88 percent of decisions are made by household heads in female-headed households, and 10 percent by spouses. The results further indicate that in male-headed households, 53 percent of decisions on storage are made by household heads, 26 percent spouses, and 20 percent by spouses and heads jointly. Overall, 61 percent of decisions on storage are made by household heads, 22 percent spouses, and 15 percent by both spouses and heads. This result simply suggests that women are more common decision-makers on storage than men, as indicated by a larger proportion of self-decision-making in female-headed households coupled with larger proportion of spousal and joint decisions in male-headed households. This further suggests that there is low power sharing in terms of decision-making in female-headed households. However, disaggregating the participation in decision-making by males and females, the results in Twelfth row of Table 5.2 indicate that 85 percent males, and 72 percent females participate, and are significant. This implies that storage decision are highly entrusted to males than females. This could be attributed to packing and staking of the produce which require physical effort which may not be of interest to females. Farm household decision on storage is very crucial as it determines the safety and quality of the crop produce. Hence, substantial knowledge of storage conditions is essential at farm level. This result is supported by the findings from the focus groups explained by the discussants as follows;

“Our produce is normally bagged after winnowing. When the bagging process is completed, the lot is normally staked in some safe place from thieves, bad weather and other factors. The staking exercise require physical effort and that this suit males more than females. Hence decision on storage are mostly done by males considering that they will eventually be the ones actually performing the activity (FFGDs). When we do the staking we exactly know how the staking is done, any disturbance we are able to notice the change and would check properly if the lot is safe from ant other malpractice, and also it makes easy for us to do the monitoring of the stored produce (MFGDs).”

Table 5. 2: Participation in decision-making on common bean farming activities disaggregated by gender

Participation in decision-making on bean farming activity	Female			Male			Chi ²
	Participate	Don't participate	n	Participate	Don't participate	n	
Site selection	152(65)	83(35)	235	116(96)	5(4)	121	S
Land/bush cleaning	151(64)	84(36)	235	120(99)	1(1)	121	S
Ridging/ploughing	152(65)	83(35)	235	120(99)	1(1)	121	S
Planting	157(67)	78(33)	235	120(99)	1(1)	121	S
Fertilizer application	105(45)	130(55)	235	57(47)	64(53)	121	NS
Pest and disease sprays	102(43)	133(57)	235	102(84)	19(16)	121	S
Harvesting	165(70)	70(30)	235	114(94)	7(6)	121	S
Produce transport	164(70)	71(30)	235	115(95)	6(5)	121	S
Threshing	178(76)	57(24)	235	93(77)	28(23)	121	NS
Winnowing	195(83)	40(17)	235	39(32)	82(68)	121	S
Sorting	184(78)	51(22)	235	84(69)	37(31)	121	NS
Storage	169(72)	66(28)	235	103(85)	18(15)	121	S

Note: In parenthesis are percentages. S (significant) and NS (not significant)

5.3.2 Binary logistic regressions on farm households' participation in decision-making on common bean production activities

5.3.2.1 Predicting farm household participation in decision-making on bean production activities.

This section uses the dependent variables as constructed and described in Section 5.2.3.1 and predictor variables as explained in Section 5.2.3.2. Based on selected bean farming activities, twelve models have been constructed to determine whether or not the farm households participate in making decisions, and hence considered to be binary response variables. The respondents were asked whether or not they participated in making decisions regarding the following bean production activities: site selection, land/bush clearing, ridging/ploughing, planting time, fertilizer application, pest & disease sprays, harvesting time, transportation, threshing, winnowing, sorting, and post-harvest storage. The decisions on bean farming activities were pre-coded as (1 if participated in decision-making, 0 otherwise). These dichotomous responses represent the dependent variables used in this section (Refer to Questions 2.10aA0 to 2.10IA0 of the survey questionnaire in Appendix 1).

With regard to the first row, models 9 and 10 in [Table 5.3](#), for every additional year of the household head age, the household head is 0.004 less likely to participate in decision-making on threshing, and 0.005 less likely on winnowing. The results suggest that as the age of the

household head increases, participation in decision-making on bean farming activities such as threshing and winnowing slowly goes down.

For household land holding size, for every extra one acre of household land holding size, the household is 0.04 less likely to participate in decision-making on pest and disease sprays and is significant. This result suggests that farm households with more land planted to common beans are less likely to make decisions on pest and disease sprays possibly because of the costs associated with pesticides. This conforms to the study by [Constantine et al. \(2020\)](#) who found availability and affordability among other key reasons for the low use of both pesticides and bio pesticides by smallholders. Hence, spraying larger acreage would attract more money which most of the smallholder farmers are constrained.

In terms of farm household head group membership, for every additional farm household group membership, the expected participation in decision-making on fertilizer application to common beans is 0.5 less likely and is significant. This result suggests that households that are affiliated to a number of farmer groups are less likely to participate in making decisions on fertilizer application to their common beans. This is reasonable because it is not a tradition in most of the Sub-Saharan African countries to apply fertilizer to common beans because common beans have the capacity to fix atmospheric nitrogen into the soil. Such information is normally shared among group members and, hence, attracts collective or reinforced decision-making before the activity is conducted and influence the alternative use of other nitrogen fixing/boosting/ access to the crop i.e. use of inoculants .

Considering the farm household size, as family size increases by one unit, the expected participation in decision-making on fertilizer application is 0.03 more likely, and the expected participation in decision-making on harvesting time is 0.02 more likely and is significant. This result implies that increases in household size increases participation in making decisions on fertilizer application and harvesting time. This is plausible because fertilizer application and harvesting are among the labour-intensive production activities which may require collective decisions before undertaking.

For gender, the results show that for male household heads, the expected participation in decision-making on site selection is 0.16 less likely, 0.14 less likely on land/bush clearing 0.19 less likely on ridging/ploughing, 0.15 less likely on planting time, 0.27 less likely on fertilizer application, 0.22 less likely on pest and disease sprays, 0.12 less likely on harvesting time, 0.14 less likely on transportation, 0.19 less likely on threshing, 0.28 less likely on winnowing, 0.15 less likely on sorting, and 0.13 less likely on post-harvest storage, and are significant. These

results show that male household heads do not participate in making decisions on common most beans production/farming activities. These results contradict the findings by [Nakazi et al. \(2017\)](#) who found no bean production activity categorized as purely done by only men or only by women, thus, concluded that bean cannot be considered a women's crop based on participation intensities since men offered support in a number of activities. These results are conceivable because dynamics in terms of classifying crops as cash crop or subsistence crops are shifting. Traditional food crops are increasingly commercialised because of rapid urbanisation, such crops are no longer taken as 'women's' crops ([Shibata et al., 2020](#)).

In connection with farm household climate change awareness, with increases in climate change awareness in the household, it is expected that participation in decision-making on fertilizer application is 0.24 less likely and is significant. This result suggests that farm households that are climate change aware have lower participation in making decisions on fertilizer application. This is plausible because farm households who are aware of the changing climate understand the effects of fertilizer despite their incredible efficiency toward contributing to increased yields of many crops including common bean. From all the focus groups (MxFGDs, FFGDs, and MFGDs) :

“The discussants explained what they perceive are the causes of climate variability and change. They cited a long list of causes which include frequent application of chemicals to treat pests and diseases in crops, fertilizer application, cutting down of trees to make charcoal, fuel wood for house use and selling and house construction, dilution of by-laws on forest management, increase in human population hence new settlements and agricultural land are opened, drying up of dambo areas results into scarcity of pasture and continuous cultivation of the field among others. More often cited and discussed in respective focus groups is chemical application to crops including fertilizer, pesticides, and herbicides. They said they are aware of climate change and its associated causes. This information is normally accessed from government, NGO agricultural extension workers, and through radios and community or village gatherings. Information about climate change is all over. We understand that we cannot harvest enough without use of synthetic fertilizers, but with crops like common beans which can still give us yields without applying fertilizer we believe it is reasonable not to apply fertilizer to save the situation of climate variability and change. It should also be pointed out that non-use of fertilizer to

common bean could be attributed to smallholder farm household economics alongside climate change awareness”.

While nitrogen fertilizer can increase crop yields, it leads to GHG emissions. After carbon dioxide and methane, N₂O is the third most important GHG, all of which deplete ozone in the stratosphere, contributing to the ozone hole (Canadell *et al.*, 2019). However, decisions on applying fertilizer to beans is of great importance as climate change is also known to increase the speed of destruction of soil minerals resulting in simplified mineral matrix due to the accumulation of minerals tolerant to weathering leading to loss of soil function for fertility maintenance and greater dependence of on mineral fertilizers (Pareek, 2017).

Referring to the study districts, the expected participation in decision-making on pest and disease sprays is 0.22 more likely in Chikwawa district compared to Dedza and is significant. Considering the tenth row and Models 5, 6 and 11 in Table 5.3, the expected participation in decision-making on fertilizer application is 0.15 less likely, 0.42 more likely on pest and disease sprays, and 0.08 less likely on sorting and are significant in Nsanje district. With reference to the eleventh row, and Models 6 and 8 in Table 5.3, the expected participation in decision-making on pest and disease sprays is 0.37 more likely, and 0.16 less likely on transportation of bean produce and are significant in Zomba district. These results suggest that participation in decision-making on some bean production activities are geographically specific and are positively and negatively related to influencing factors. As attributed to the FGDs, the participation in decision-making on common bean activities that require cash involvement, expertise, resource ownership is dominated by men(husbands) while participation in decision-making on activities requiring physical engagement or demand more time attract joint decisions. Similarly, decisions on activities that seem to be time-consuming, but require less physical effort, are dominated by women (wives). One of the participants from a female focus group discussions (FFGDs) highlighted:

“Our husbands normally do not engage us in making decisions regarding some bean farming activities, more especially the so called ‘easy’ activities. Further, she said in any activity attached to finances, it has always been noted that our husbands come and dictate on how to go about it and eventually take us out of the decisions. By contrast, one participant from the male focus group discussions indicated that women themselves normally detach themselves from making decisions regarding the farming activities including those of bean production.

What they do most of the time is to agree what the husbands are proposing or suggesting”.

The FGDs results and narratives of participation in decision-making on bean farming activities contradict those from the regression models of the selected bean activities, such that there are negative relationships between gender and the participation decision-making in all the bean farming activities. This is not surprising because there are more elaborate explanations in the FGDs in extracting information than in mostly pre-coded data collection tools, such as structured survey schedules. Therefore, proper framing of questions in the survey schedules is imperative to capture information in the best way possible. Similarly, in FGDs, discussants sometimes change their opinion due to the influence of other members of the groups leading to conflicting information (Wolff *et al.*, 2014).

Table 5. 3: Marginal effects of binary logistic regression models of participation in decision-making on common bean production activities.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Marginal effects (dy/dx) of farm household participation in decision-making on bean production activities					
	Site selection	Land/bush clearing	Ridging/ploughing	Planting time	Fertilizer application	Pest & disease sprays
Age of household head	0.000(0.003)	0.000(0.003)	-0.001(0.003)	-0.002(0.003)	-0.003(0.004)	-0.002(0.003)
Land holding size	-0.013(0.015)	-0.014(0.015)	-0.004(0.015)	-0.004(0.015)	-0.036(0.022)	-0.036 *(0.020)
Group membership	-0.017(0.020)	0.003(0.021)	0.003(0.020)	-0.000(0.020)	-0.047 *(0.027)	-0.009(0.026)
Bean farming experience	0.000(0.003)	-0.001(0.003)	-0.004(0.003)	0.000(0.003)	-0.005(0.004)	-0.004(0.004)
Family size	0.016(0.013)	0.016(0.013)	0.020(0.013)	0.021(0.013)	0.035 **(0.016)	0.018(0.016)
Gender	-0.157 **(0.066)	-0.144 *(0.066)	-0.190*** (0.063)	-0.148 *(0.063)	-0.271 *** (0.089)	-0.218 *** (0.082)
Literacy	0.043(0.059)	-0.014(0.059)	-0.002(0.058)	0.006(0.057)	0.039(0.075)	0.114(0.072)
Climate change awareness	-0.021(0.094)	-0.071(0.094)	-0.068(0.091)	-0.092(0.092)	-0.242 *(0.122)	-0.096(0.115)
Chikwawa	-0.025(0.078)	0.043(0.072)	0.051(0.070)	0.053(0.072)	-0.071(0.091)	0.225 *** (0.083)
Nsanje	-0.018(0.075)	0.034(0.071)	0.036(0.069)	-0.035(0.071)	-0.153*** (0.088)	0.417 *** (0.080)
Zomba	-0.059(0.079)	-0.013(0.074)	-0.003(0.072)	-0.031(0.073)	-0.340(0.085)	0.367 *** (0.079)
Classification accuracy correctly predicated	75.4%	75.7%	76.3%	77.3%	66.2%	71.0%
Log-likelihood	-171.21	-171.31	-166.72	-163.98	-190.14	-192.54
LR Chi ²	(11) = 11.33	(11) = 8.87	(11) = 13.47	(11) = 11.72	(11) = 56.52	(11) = 46.13
Pseudo R ²	0.14	0.12	0.14	0.13	0.22	0.21

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Dedza district as the reference category

Table 5.3 cont'd. Marginal effects of binary logit regression models of participation in decision-making on common bean production activities.

Model	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Marginal effects(dy/dx) of farm household participation in decision-making on bean production activities					
	Harvesting time	Transportation	Threshing	Winnowing	Sorting	Storage
Age of household head	-0.002(0.003)	-0.002(0.003)	-0.004 *(0.003)	-0.005 *(0.003)	-0.001(0.003)	-0.001(0.003)
Land holding size	-0.002(0.014)	-0.005(0.014)	-0.004(0.015)	-0.015(0.018)	0.002(0.015)	-0.012(0.015)
Group membership	-0.002(0.019)	-0.006(0.019)	-0.000(0.021)	0.005(0.024)	0.017(0.022)	0.024(0.021)
Bean farming experience	0.001(0.003)	0.001(0.003)	0.004(0.003)	0.004(0.004)	0.002(0.003)	0.004(0.003)
Family size	0.025 *(0.013)	0.017(0.012)	0.016(0.013)	-0.002(0.014)	-0.007(0.013)	-0.015(0.012)
Gender	-0.118 *(0.062)	-0.138 *(0.063)	-0.186 *** (0.064)	-0.284 *** (0.077)	-0.146 ** (0.069)	-0.126 *(0.068)
Literacy	-0.006(0.055)	0.040(0.055)	0.066(0.060)	-0.034(0.067)	-0.023(0.060)	0.003(0.058)
Climate change awareness	-0.084(0.088)	-0.142(0.091)	0.040(0.095)	-0.078(0.106)	-0.022(0.097)	0.029(0.093)
Chikwawa	-0.049(0.080)	-0.147(0.088)	0.017(0.077)	-0.101(0.092)	0.070(0.076)	-0.023(0.077)
Nsanje	-0.129(0.078)	-0.161(0.084)	-0.038(0.077)	-0.116(0.090)	-0.082 ** (0.078)	-0.049(0.077)
Zomba	-0.119(0.080)	-0.158 *(0.087)	-0.112(0.080)	-0.244(0.093)	-0.103(0.080)	-0.065(0.080)
Classification accuracy correctly predicted	78.5%	77.3%	75.4%	67.2%	73.8%	74.8%
Log-likelihood	-158.19	-160.26	-168.08	-185.90	-173.26	-168.28
LR Chi2	(11) = 13.22	(11) = 19.17	(11) = 17.58	(11) = 38.74	(11) = 15.91	(11) = 14.92
Pseudo R2	0.15	0.14	0.14	0.19	0.13	0.13

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Dedza district as the reference category

5.3.3. Farm household involvement in performing common bean production activities.

5.3.3.1 Site selection

Referring to the first row of Table 5.4, approximately 83 percent of site selection is pursued by households' heads in female-headed households, while 44 percent is recorded in male-headed households. By contrast, 11 percent of site selection is performed by spouses in female-headed households, while in male-headed households, 29 percent of site selection is done by spouses. Other direct involvement indicates that 25 percent of site selection is pursued jointly (household head and spouses) in male-headed households. Across both male and female-headed households, 53 percent, 24 percent and 19 percent of site selection is directly performed by household heads, spouses, and jointly, respectively. This result suggests that females are much more involved in site selection than males, as indicated by the highest proportion of involvement of household heads in female-headed households. Again, reasonable proportions of spousal and joint involvement are reported in male-headed households. This is not surprising because direct involvement in site selection requires some history of the land and knowledge of the environment in which to grow the common beans, areas where household heads and spouses are well placed. However, the results on direct involvement in site selection disaggregated into male and female respondents (first row of Table 5.5) indicate that, 93 percent of the males, and 64 percent of the females engage in site selection. This could be attributed to issues of land ownership which in most cases males take control over most of the farm household resources including land. The results from the focus group discussions support this finding as follows;

“We take an initiative to directly engage into site selection while our females are doing other equally important household chores. Knowing that we are usually the alludols of the land, we plan its land use that’s knowing exactly what crop is expected to be planted to which piece of land or should be used for what purpose based on experience and the amount of the budget allocated to each commodity within the household (MFGDs). Where land is owned and controlled by us, the direct involvement in site selection is always possible and this is particularly common in female headed households (FFGDs).”

Site selection is crucial to the production of several crops because some need or grow well in specific environments, which if not considered well, may result in low yields or total crop failure. Again, planting location can have a significant effect on potential production ([Degomez & Call, 2013](#)).

5.3.3.2 Land/bush clearing

In relation to direct engagement in land/bush clearing, in female-headed households, approximately 36 percent of land or bush clearing is carried out by household heads, while 40 percent is discharged by household heads and other household members, and 12 percent by others. While in male-headed households (second row), approximately 54 percent of notable direct involvement in land or bush clearing is pursued jointly (household head and spouse), and 26 percent by household head and other household members. Across female and male-headed households, 14 percent, 42 percent, and 29 percent of land or bush clearing is discharged by household heads, joint, and household heads and other household members respectively. The result suggests that involvement in land/bush clearing is spread across household members and beyond. This could be because of the nature of the activity which requires physicality and more effort to perform. This is shown by the higher rate of division of labour and inclusion in both female and male-headed households. Although the farm household involvement in land/bush clearing are statistically significant for both male and female-headed households (Table 5.5), the results disaggregated into male and female direct involvement in land/bush clearing, are statistically insignificant.

5.3.3.3 Ridging/ploughing

In connection with direct involvement in undertaking ridging or ploughing, in female-headed households about 33 percent of ridging or ploughing is performed by household heads, and 43 percent by household heads and other members. This is somewhat different in male-headed households where 54 percent of actual involvement in ridging is carried out jointly (household head and spouses), 27 percent by household heads and other members, and 14 percent others. Over the female and male-headed households, 31 percent of ridging is made by household heads and other members, and 12 percent others. This result suggests considerable joint effort in undertaking ridging or ploughing, as indicated by higher proportions of joint involvement by spouses and heads, and other household members and heads. This further suggests that ridging or ploughing are activities that have to be performed within a specific timeframe in readiness for planting. Any delays would result in late planting and the onset of rains may find

the field unprepared. In view of this, households employ the use of joint effort to speed up the activity in order to target the first planting rains. Despite all these, the results disaggregated into male and female respondents on their engagement in field ridging/ ploughing, indicate statistical insignificance (third row of Table 5.5).

5.3.3.4 Planting

For direct involvement in carrying out planting, 33 percent of common beans planting is actually done by household heads, 43 percent by household heads and other members, and 10 percent by others. This is somewhat different from male-headed households where 52 percent is pursued jointly (household head and spouse), 31 percent by household heads and other members, and 10 percent by others. Across female and male-headed households, approximately 10 percent of common bean planting is performed by household heads, 41 percent jointly, 34 percent household heads and others, and 10 percent by others. This result suggests that household heads in female-headed households are highly engaged in planting common beans than in male-headed households. With reference to joint (heads and spouses) involvement, there is a higher engagement in male-headed households than in female-headed households in common bean planting. Finally, there is more engagement of household heads and other household members in female-headed households than in male-headed households. The joining of hands in the planting activity of common beans is usually geared towards finishing planting within the shortest time possible. This is aimed at achieving growth uniformity of the crop stand, and to cover a stipulated area while there is enough moisture in the soil to ensure higher germination percentages. Planting dates are important in achieving higher seed yield, seed weight, harvest index and canopy dry weight ([Acosta-gallegos et al., 1996](#)). In terms of how males and females engage in planting in the face of climate variability and change, the results in the fourth row of Table 5.5 show statistical insignificance.

5.3.3.5 Fertilizer application

Referring to fertilizer application in female-headed households, approximately 21 percent of fertilizer application in common beans is done by household heads, 19 percent by household heads and other members, and 47 percent by others. However, in male-headed households, 30 percent is done jointly, 14 percent by household heads and other members, and 51 percent by others. Notably, across female and male-headed households, 24 percent of fertilizer application is performed jointly, 15 percent by household heads and other members, 15 percent by spouses and other household members, 50 percent by others. This result suggests a low involvement in

fertilizer application by household heads, and spouses. This may be because most farmers in Malawi do not apply fertilizer to their bean crop if it is grown in pure stand. However, higher proportions of combined effort between the household heads and their spouses, household heads and other household members are attributed to farmers who intercrop beans with maize due to their environmental and socio-economic benefits of intercropping systems to increase crop diversity and reduce use of external inputs on cereal (Jensen *et al.*, 2020; Stagnari *et al.*, 2017). Despite statistically significant involvement of male and female –headed households in applying chemical fertilizer to their common beans, the results disaggregated into male and female direct involvement, show statistical insignificance (fifth row of Table 5.5).

5.3.3.6 Pest and disease sprays

As with direct involvement in pest and disease sprays, 31 percent of actual spraying against pest and disease in common bean farming is done by household heads, 19 percent by household heads and other members, and 37 percent by others in female-headed households. Whilst in male-headed households (sixth row), 22 percent of actual spraying against pests and diseases is performed by household heads, 11 percent by spouses, 28 percent jointly, and 29 percent by others. Significantly, across the female and male-headed households, 24 percent of pest and disease sprays are done by household heads, 10 percent by spouses, 21 percent jointly, 11 percent by household heads and other members, and 32 percent by others. This result suggests that there is higher involvement of household heads in spraying against pests and diseases, followed by a combined effort of household heads and their spouses. Generally, these represent smaller percentages of the population implying little activity of pest and disease sprays at household level. The proportion ‘others’ shows those households that are not involved in application of chemical against pest and diseases. This is not surprising, though pests and diseases pose a big threat to common bean production, most farmers in African countries, including Malawi, tend to neglect pest and diseases spraying because of the high cost of synthetic pesticides (Sola *et al.*, 2014). However, looking at the sixth row of Table 5.5, the results disaggregated into male and female direct involvement in pest/disease sprays, indicate that 78 percent of males, and 45 percent of females engage in pest/disease sprays and are significant. The results clearly indicate that males are more likely to be involved in pest/disease sprays than females. This could be attributed to the skills, knowledge and awareness of use of pesticides which males normally have and possess. This result is further supported by explanation explored from the focus group discussions as follows;

“We participate in many groups where we get a lot of information about farming activities including pest and disease sprays and therefore are more knowledgeable, skilled and aware of recent innovations than females. This makes us have confidence in undertaking some farming activities better than females. Additionally, there is an element of more physical effort required especially the backload of the spraying equipment using over a given area of land. It is an activity that is not simple and this restrains females for direct involvement (MFGDs)”.

5.3.3.7 Harvesting

Based on the seventh row of [Table 5.4](#), 31 percent of harvesting of common bean in female-headed households is done by household heads, 46 percent by household heads and other members, and 10 percent by spouses and other household members. On the other hand, in male-headed households (seventh row), 49 percent of harvesting common beans is performed jointly, 38 percent by household heads and other members. Notably, across female and male-headed households, 39 percent of harvesting is carried out jointly, 40 percent household heads and other members. Harvesting common beans is so demanding considering its shattering characteristic which, when delayed, may result in a huge loss of crop yield. This translates into engaging enough labour force, typically including a combination household heads and other household members and spouses with other household members. In addition, external sources of labour are hired to accomplish harvesting before the common bean pods start shattering. Despite the importance of direct involvement in harvesting common beans, in both male and female-headed households, the results disaggregated into male and female respondents (the seventh row of Table 5.5), indicate statistical insignificance.

5.3.3.8 Transportation

With respect to transportation, 28 percent of transportation of common beans from the fields to homes is conducted by household heads, 52 percent by household heads and other household members, and 10 percent spouses and other household members in female-headed households. By contrast, in male-headed households, 47 percent of transportation of common beans from fields to homes is pursued jointly, and 35 percent by household heads and other household members. Across female and male-headed households, 38 percent of transportation of beans from fields to homes is jointly, and 39 percent by household heads and other household members. This result suggests that transportation of beans from fields requires combined effort

to speed up the process, otherwise farmers may risk their crop produce being stolen. This is supported by a remarkable combined involvement by household heads and other household members in both female and male-headed households, and joint effort between heads and their spouses in male-headed households. Transportation of common beans from the fields to homes for further processing require urgency because the harvested bean can easily be stolen if left in the field after harvesting. Again, transportation of common bean from the field to homes is more often done on headload by most of the smallholder farmers because they do not own transporting machinery or equipment and cannot afford hired transport. However, the results from disaggregated male and female respondents (eighth row of Table 5.5), show statistical insignificance on how they are directly involved in produce transportation.

5.3.3.9 Threshing

With regard to threshing, approximately 40 percent of common bean threshing in female-headed households is performed by household heads, 37 percent by household heads and other household members, 10 percent by spouses and other household members, and 7 percent by others. By contrast, in male-headed households, 19 percent is discharged by household heads, 8 percent by spouses, 37 percent jointly, and 23 percent by household heads and other household members. Across female and male-headed households, 24 percent of threshing is performed by household heads, 30 percent jointly, 27 percent household heads and other household members, 8 percent by spouses and other household members, and 5 percent by others. These results suggest that a larger percentage of females is directly involved in threshing in female-headed household than in male-headed household. Again, the results further suggest that threshing requires combined effort, as shown by reasonable percentages of combined effort of household heads and other household members in both female and male-headed households. In terms of male and female direct involvement in bean threshing, the results in the ninth row of Table 5.5 show that 67 percent males and 87 percent females directly engage in threshing of common beans. This indicates that females are more involved in bean threshing than males. This could be attributed to the fact that females spend more time at home, where the harvest is stored for threshing while the males are normally out of home. Hence, to avoid the risk of losing the harvest through pests i.e., goats, sheep and even cattle which normally feed around the homesteads, females normally take charge. Once the common bean is transported from the fields to homes, it is kept in places where it is expected to dry completely ready for threshing. It is an activity that needs to be done with speed because, depending on the place of drying, the

produce can be attacked by termites which can lead to reduction in the crop harvest eventually. This finding is supported by the focus group discussions as follows;

“Once common bean is harvested, it is transported home with the husks and sometimes the whole semi-dried plant. Though sun drying is done at home where most of the livestock, children are. Common bean husks and semi dried plants are a delicacy for small livestock as goats and sheep. Because most of the activities done by females are within or around the homestead, they normally take charge of the crop produce. Once the harvested crop is near or completely dried, it starts shattering and needs to be threshed at that point. Who normally notice that, are females who operates from within the homestead and are eventually the ones who perform the threshing (FFGDs). However, when we are not too engaged with other activities, we take part in threshing along with the females but normally this is rare as we mostly are not at home and can’t easily noticed whether or not the bean is ready for threshing (MFGDs)”.

5.3.3.10 Winnowing

Considering direct engagement in winnowing, 55 percent of winnowing of common bean in female-headed household is performed by household heads, 5 percent by spouses, 28 percent by household heads and other household members, 7 percent by spouses and other household members, and 4 percent by others. By contrast, in male-head households approximately 41 percent of winnowing is performed by household heads, 28 percent by spouses, 7 percent jointly, 7 percent by household heads and other household members, 15 percent by spouses and other household members, and 3 percent by others. Across male and female-headed households, 44 percent is performed by household heads, 22 percent by spouses, 5 percent jointly, 12 percent by household heads and other household members, 13 percent by spouses and other household members, and 3 percent by others. This result suggests that females engage more highly in winnowing of common bean than males, supported by a higher proportion of involvement by household heads, and heads and other household members in female-headed households, against a higher proportion of spousal involvement in male-headed households. Furthermore, looking at the tenth row of Table 5.5, the results disaggregated into male and female direct involvement in winnowing show that 11 percent males, and 88 percent females engage in winnowing. This suggests a clear majority of females are directly involved in winnowing than males. Winnowing is normally done using a bamboo weaved shallow basket

which is normally used by women and therefore, dominance of females in this bean farming activity could be attributed to that.

Table 5. 4: A two-way table of frequencies of farm household involvement in performing common bean production activities

Activity	Household direct involvement in bean farming activities (% in brackets)					
	Self	Spouse	Self & spouse jointly	Self & other HH members	Spouse & other HH members	Others
<i>Female-headed household</i>						
Site selection	69(83)	9(11)	1(1)	3(4)	1(1)	0(0)
Land/bush clearing	30(36)	4(5)	2(2)	33(40)	4(5)	10(12)
Ridging/ploughing	27(33)	2(2)	4(5)	36(43)	7(8)	7(8)
Planting	27(33)	2(2)	3(4)	36(43)	7(8)	8(10)
Fertilizer application	17(21)	1(1)	3(4)	16(19)	7(8)	39(47)
Pest and disease sprays	26(31)	3(4)	1(1)	16(19)	5(6)	32(37)
Harvesting	26(31)	1(1)	3(4)	38(46)	8(10)	7(8)
Transportation	23(28)	2(2)	2(2)	43(52)	8(10)	5(6)
Threshing	33(40)	2(2)	3(4)	31(37)	8(10)	6(7)
Winnowing	46(55)	4(5)	1(1)	23(28)	6(7)	3(4)
Sorting	40(48)	4(5)	1(1)	30(36)	6(7)	2(2)
Storage	61(74)	10(12)	0(0)	9(11)	2(2)	1(1)
<i>Male-headed household</i>						
Site selection	119(44)	78(29)	68(25)	4(2)	3(1)	1(0)
Land/bush clearing	18(7)	7(3)	147(54)	71(26)	5(2)	25(9)
Ridging/ploughing	6(2)	3(1)	147(54)	73(27)	7(3)	37(14)
Planting	7(3)	1(0)	143(52)	85(31)	10(4)	27(10)
Fertilizer application	5(2)	2(1)	81(30)	37(14)	8(3)	140(51)
Pest and disease sprays	60(22)	31(11)	75(28)	23(8)	4(2)	80(29)
Harvesting	7(3)	1(0)	134(49)	104(38)	12(4)	15(6)
Transportation	11(4)	2(1)	129(47)	95(35)	11(4)	25(9)
Threshing	53(19)	21(8)	102(37)	64(23)	21(8)	12(4)
Winnowing	112(41)	75(28)	18(7)	20(7)	41(15)	7(3)
Sorting	60(22)	19(7)	106(39)	55(20)	28(10)	5(2)
Storage	121(44)	52(19)	89(33)	5(2)	3(1)	3(1)
<i>Across male and female-headed household</i>						
Site selection	188(53)	87(24)	69(19)	7(2)	4(1)	1(0)
Land/bush clearing	48(14)	11(3)	149(42)	104(29)	9(3)	35(10)
Ridging/ploughing	33(9)	5(1)	151(42)	109(31)	14(4)	44(12)
Planting	34(10)	3(1)	146(41)	121(34)	17(5)	35(10)
Fertilizer application	22(6)	3(1)	84(24)	53(15)	15(4)	179(50)
Pest and disease sprays	86(24)	34(10)	76(21)	39(11)	9(3)	112(32)
Harvesting	33(9)	2(1)	137(39)	142(40)	20(6)	22(6)
Transportation	34(10)	4(1)	131(38)	138(39)	19(5)	30(8)
Threshing	86(24)	23(7)	105(30)	95(27)	29(8)	18(5)
Winnowing	158(44)	79(22)	19(5)	43(12)	47(13)	10(3)
Sorting	100(28)	23(7)	107(30)	85(24)	34(10)	7(2)
Storage	182(51)	62(17)	89(25)	14(4)	5(1)	4(1)
<i>Overall</i>						
Involvement units	84(24)	28(8)	105(30)	79(22)	19(5)	41(12)

Note: $n = 356$ and Percentages in parenthesis

The results from the focus group discussions support this finding as follows;

“The common way of winnowing in smallholder farming is the use of the bamboo winnower. This equipment requires an art and experience to properly undertake the winnowing which is mostly rare in males. Females know how to shake and swerve the winnower which in the process separates the chaff and other concoctions from the bean grain. It is not surprising to see females dominating in this activity as much as most males may have wished to directly engage themselves in winnowing but can do it perfectly (FFGDs)”

5.3.3.11 Sorting

Considering direct involvement in sorting, in female-headed households, 44 percent of sorting of common beans is carried out by household heads, 5 percent spouses, 36 percent household heads and other household members, 7 percent spouses and other household members, and 2 percent others. On the other hand, in male-headed households around 22 percent of sorting is performed by household heads, 7 percent spouses, 39 percent jointly, 20 percent household heads and other household members, 10 percent spouses and other household members, and 2 percent. Across the households, approximately 28 percent of sorting is done by household heads, 7 percent spouses, 30 percent jointly, 24 percent household heads and other household members, 10 percent spouses and other household members, and 2 percent others. This result suggests sorting requires a combined effort, as supported by a higher proportion of heads and other household members in female-headed households, and a higher proportion too in heads and the spouses jointly, heads and other household members, spouses and other household members in male-headed households. In most cases, sorting of common bean at farm level is done in order to satisfy market requirements as some buyers require small seeded grains whilst others may require large seeded beans/grains. Again, sorting is normally done to separate defected or infected seeds etc. from whole or healthy seed. This improves storability of the seed for the next growing season, because infected ones would result in infection distribution across the seed store. Based on the results from the disaggregated male and female respondents (eleventh row of Table 5.5), on how they engage in sorting of common beans, 90 percent of females, and 66 percent of the males engage in sorting. A clear majority of females engage in sorting than males. This could be attributed to the time taken or required to do sorting. Sorting is normally a slow process and takes a lot of time, hence, as females normally spend more time in their homes, this activity looks feasible for them than males who normally enjoy mobility.

This finding is supported by the focus group discussions as follows;

“Mostly, sorting is done to achieve uniformity in the grain in terms of size, improve quality i.e. free from broken or moulded/rotten grain. These are done to satisfy market needs and sometimes improve storability. This exercise needs patience and concentration as is a very slow process. Due to involvement of males into different activities, they find it difficult to directly engage into it considering the time it takes to sort a reasonable amount of grain. While when women are doing the sorting of the grain they also put aside the grain that is fairly good for consumption, a thing which males may find it difficult to isolate (MxFGDs)”.

5.3.3.12 Storage

Looking at the twelfth row of Table 5.4, in female-headed households, storage of common beans is performed by 74 percent of household heads, 12 percent spouses, 11 percent heads and other household members, and 2 percent spouses and other household members. By contrast, in male-headed households, 44 percent of storage of common beans is carried out by household heads, 19 percent spouses, 33 percent jointly, and 2 percent household heads and other household members. Across female and male-headed households, about 51 percent of post-harvest storage of common beans is conducted by household heads, 17 percent spouses, 25 percent jointly, and 4 percent heads and other household members. This result suggests that household heads in both male and female-headed households are highly involved in storage of common bean produce. However, despite the dominance of women's involvement in storing common bean in female-headed households, there is a reasonable proportion of combined involvement in storing common beans which may encourage responsibility in monitoring the status of the crop produce by both spouses or household heads, and other household members. Considering the disaggregated male and female direct involvement in storing common beans, the results in the twelfth row of Table 5.5, show statistical insignificance.

Table 5.5: Direct involvement in performing common bean farming activities disaggregated by gender

Engagement in decision-making on bean farming activity	Female			Male			Chi ²
	Engage	Don't engage	<i>n</i>	Engage	Don't engage	<i>n</i>	
Site selection	151(64)	84(36)	235	113(93)	8(7)	121	S
Land/bush cleaning	196(83)	39(17)	235	105(87)	16(13)	121	NS
Ridging/ploughing	195(83)	40(17)	235	98(81)	23(19)	121	NS
Planting	203(86)	32(14)	235	98(81)	23(19)	121	NS
Fertilizer application	109(46)	126(54)	235	50(41)	71(59)	121	NS
Pest and disease sprays	107(45)	128(55)	235	94(78)	27(22)	121	S
Harvesting	210(89)	25(11)	235	102(84)	19(16)	121	NS
Produce transport	204(87)	31(13)	235	99(82)	22(18)	121	NS
Threshing	205(87)	30(13)	235	81(67)	40(33)	121	S
Winnowing	207(88)	28(12)	235	13(11)	108(89)	121	S
Sorting	212(90)	23(10)	235	80(66)	41(34)	121	S
Storage	191(81)	44(19)	235	94(78)	27(22)	121	NS

Note: In parenthesis are percentages, NS-not significant, S-significant at 0.005.

5.3.4 Binary logistic regressions on farm households' direct involvement in performing common bean production activities

5.3.4.1 Predicting household involvement in performing bean production activities

The construction of the dependent variables is based on farm household direct involvement in undertaking bean farming activities. The respondents were asked whether or not they directly engaged in performing bean farming activities which include site selection, land/bush clearing, ridging/ploughing, planting time, fertilizer application, pest & disease sprays, harvesting time, transportation, threshing, winnowing, sorting, and post-harvest storage. The direct involvement in such activities were pre-coded as (1 if directly involved, 0 otherwise). These dichotomous responses represent the dependent variables used in this section (Refer to Questions 2.10aA2 to 2.10IA2 of the survey questionnaire in Appendix 1).

Table 5.6 presents the marginal effects of binary logistic regressions on farm household involvement in performing bean production activities. Considering the first row of Models 7 and 9 in Table 5.6, an increase in the age of household head by one year reduces the expected involvement in common bean harvesting by 0.003, and 0.01 in threshing and is significant.

This suggests that, as farm household heads get older, their engagement in performing some bean production activities, i.e., harvesting and threshing among others decrease. This is conceivable because physical strength is required during the process of agricultural production, i.e., harvesting and threshing which declines in adult farmers after middle age and necessitates non-engagement in such production activities (Guo *et al.*, 2015).

Referring to the land holding size and Model 12, for every extra acre of farm household land holding size, the expected direct engagement in post-harvest storage of common bean is 0.03 more likely and is significant. This result suggests that farm households with larger land holding sizes are more likely to have more produce that may require more storage space or facilities. This is plausible because under normal circumstance it is expected that larger land holding sizes can result into increased yields. However, the study by Wickramarachchi & Weerahewa (2018) on relationship between land size and productivity found mixed results, thus, a clear positive relationship between land size and productivity, particularly in many developing countries, and an inverse relationship between land size and productivity as land size increased beyond a certain limit. Hence, it is not surprising to have a positive relationship between land holding size and storage.

With reference to bean farming experience and Models 4, 5, 7,8, 9 and 11, for every additional year of bean farming experience, the expected direct involvement in planting common beans is 0.004 more likely, 0.01 less likely in fertilizer application, and 0.004 more likely in harvesting, 0.01 more likely in transportation, threshing and sorting and are significant. These results suggest that farm household with more years of bean farming experience directly engage in planting, harvesting, transporting, threshing, and sorting of common beans. However, their engagement in fertilizer application decreases with experience. These results are conceivable because considering how farmers perceive onset, ending, and the amount of main rainfall season, planting becomes a crucial production activity in that it has to be done timely, which relies on the experience of the farmers to reduce mistargeted planting. Over the years that a farm household has been growing beans, it has learned much about production activities, including that of fertilizer application. Fertilizer application is not a traditional practice in bean farming in most of Sub-Saharan Africa as it requires experienced individual farmers to undertake the activity. Further, harvesting is a vital production activity in common bean farming which has to be done carefully with individual farmers understanding the appropriate timing and the actual harvesting based on experience. To avoid post-harvest loss, i.e., loss due

to livestock or to theft, experienced farmers arrange transportation of the bean produce. Common beans are normally harvested and transported to the homestead together with their stalks. When the stalks and the pods are dry enough, they are ready for threshing, hence, it takes an experienced farmer to time such an activity to avoid reduce post-harvest losses. Threshed common beans are sorted based on storability and marketing characteristics based on an individual farmer's experience. Therefore, it is not surprising to have a positive relationship between bean farming experience and key production activities.

With regard to family size and Models 4, 11 and 12, for every additional family member in a household, the expected direct involvement in planting, sorting, and storage is 0.02 less likely, and is significant. The results suggest that larger families have reduced direct involvement in planting, sorting and storage. This is intriguing because in principle, larger families are expected to provide more labour force, hence, be directly engaged into production activities. However, where family members are much more into off-farm activities, it is unlikely that larger family sizes could lead into increased involvement in bean farming activities. Further, the results somehow agree with a study by [Shapiro \(1990\)](#) who attests that there is a decline in cultivated area per member as household size increases that may reflect and spur problems as well as a propensity toward greater diversification of household activities as household size increases.

Looking at gender and Models 1, 2, 4, 7 and 10, male household heads' expected direct involvement in site selection is 0.16 less likely, 0.14 more likely in land or bush clearing, 0.18 more likely in planting, 0.10 more likely in harvesting, and 0.23 less likely in winnowing, and is significant. These results suggest that male household heads (men) do not normally engage in site selection for common bean fields and winnowing. However, they directly engage in land or bush clearing, planting and harvesting. These results repudiate the study by [Duncan & Brants \(2004\)](#) who attest that control over resources, including land, is strongly associated with land ownership, as allodial owners (real owner of the land) have the right to take key decisions with regard to the land (i.e., which investments to make, whether or not to sell the land, etc.) and that males are dominant in such decision-making. A negative relationship between male household heads and site selection could be attributable to delegation of powers and inclusivity in male-headed farm households. These results further imply that the mixture of negative and positive relationships between gender and some selected bean production activities is ascribed

to the fact that, though common beans cease to be a feminine crop due to recent dynamics of its importance, there are still traces of femininity in its production chain.

Making reference to literacy levels and Model 2, , the expected direct involvement in land/bush clearing by literate farm households is 0.13 less likely and is significant. This result suggests that literate farm households do not normally engage in land/bush clearing of bean fields. This is likely because education plays an important role in how best individual farmers engage in farming activities and is consistent with the findings by [Paltasingh & Goyari \(2018\)](#) who found that education enhances farm productivity in the case of adopters of modern technologies and are perceived to have the capacity to hire labour i.e. minimum tillage technologies, and use of herbicides.

Regarding climate change awareness and Model 5, as climate change awareness in farm households increases by one unit, the expected direct involvement in fertilizer application is 0.23 less likely and is significant. This result suggests that, compared to farm households that are climate change unaware, farm households that are climate change aware do not directly engage in fertilizer application to common beans. Across the focus group (MxFGDs, FFGDs, and MFGDs):

“The discussants explained that their access to climate change information is packaged alongside with other information of agricultural production activities. We are aware of the importance of fertilizer application to our crops as we normally are trained by the NGOs and government agricultural extension workers, who also train us about how leguminous crops produce reasonable amount of yield without applying fertilizers and how that can be improved with fertilizer application. Such kind of messages unveil advantages and disadvantages of producing a crop including common bean with or without fertilizer application. Knowing that the impacts of climate change are more devastating, many do not engage into fertilizer application to most of the leguminous crops including common beans as have capacity to fix atmospheric nitrogen into the soil. Smallholder farmers who are climate change aware are among the farmers who are on top in accessing most of agricultural production information and would not risk embarking onto a production activity with associated long-term consequences”

However poor, low soil phosphorus (P), nitrogen (N) and poor biological N₂-fixation call for supplementation of other nutrients that cannot be fixed by biological fixation to achieve higher yields (Chekanai *et al.*, 2018). These limitations are attributable to climate change and have been known to negatively affect soil fertility which would intensify food insecurity (St.Clair & Lynch, 2010).

With reference to study districts and Models 4, 5, 6 and 11, compared to Dedza district, the expected direct involvement in planting by farm households in Chikwawa district is 0.08 less likely, 0.10 less likely in fertilizer application, 0.30 more likely in pest and disease sprays, and 0.11 more likely in sorting and are significant. In Nsanje district, the expected direct involvement in land/bush clearing in Nsanje district is 0.04 less likely, 0.09 less likely in ridging/ploughing, 0.27 less likely in planting, 0.26 less likely in fertilizer application, and 0.16 less likely in storage, and are significant. Finally, referring to Zomba district and Models 6, the expected direct involvement in pest and disease sprays is 0.38 more likely, and is significant. These results imply that districts with more farm households are less likely to engage in most of the bean farming activities, as this decreases the share for each member at household level to undertake a particular activity. In particular geographical locations, a positive relationship between farm household populations and the bean farming activities could be attributed to their labour intensiveness (Shapiro, 1990). From the focus group discussions, the discussants unanimously indicated that direct involvement in undertaking common bean production activities requires support from family members just like any other crop, however, it also arose that specific activities are normally performed by either women or men. Looking at the activities which are dominated by men, it is clear that they have the connotations of physical effort requirement or emerge at a critical stage of production, thorough knowledge of the activity, and monetary benefits. Notwithstanding, most bean farming activities are conducted jointly. One of the participants in a mixed focus group discussions (MxFGDs) explained:

“Sometimes our husbands leave us alone to perform almost all of the bean production activities, we become surprised to see them taking control during the time when crop is mature and ready for marketing. Common bean is one of the crops which is short duration (though there are other varieties which are long duration especially the climbers), this forces us to be available at the marketing node of production to benefit the proceedings when other crops are ready for marketing”.

Table 5. 6: Marginal effects of binary logit regression models of farmers' direct involvement in performing common bean production activities.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Marginal effects ($dE(y)/dx$) of farm household direct involvement in performing bean production activities						
Variable	Site selection	Land/bush clearing	Ridging/ploughing	Planting	Fertilizer application	Pest & disease sprays
Age of household head	0.002(0.003)	-0.001(0.002)	-0.003(0.002)	-0.001(0.002)	-0.002(0.004)	-0.004(0.003)
Land holding size	-0.024(0.015)	-0.009(0.011)	-0.014(0.012)	-0.007(0.010)	-0.037(0.022)	-0.031(0.020)
Group membership	-0.004(0.021)	0.023(0.017)	0.008(0.018)	0.018(0.016)	-0.030(0.028)	-0.026(0.026)
Bean farming experience	0.000(0.003)	0.001(0.002)	0.004(0.003)	0.004 * (0.002)	-0.007 * (0.004)	0.002(0.004)
Family size	0.006(0.013)	-0.006(0.009)	-0.004(0.010)	-0.017 ** (0.008)	0.005(0.017)	0.010(0.015)
Gender	-0.165 ** (0.069)	0.136 ** (0.062)	-0.045(0.061)	0.185 *** (0.063)	0.052(0.090)	-0.049(0.084)
Literacy	0.042(0.061)	-0.128 *** (0.043)	-0.067(0.049)	-0.058(0.039)	-0.044(0.076)	0.051(0.073)
Climate change awareness	-0.147(0.097)	-0.012(0.074)	-0.025(0.085)	-0.011(0.069)	-0.233 * (0.130)	0.137(0.115)
Chikwawa	-0.054(0.080)	0.000(0.066)	-0.013(0.074)	-0.079 ** (0.084)	-0.103 * (0.093)	0.296 ** (0.082)
Nsanje	0.032(0.076)	-0.040 *** (0.064)	-0.090 ** (0.073)	-0.271 ** (0.090)	-0.263 *** (0.087)	0.433(0.080)
Zomba	-0.048(0.080)	-0.255(0.073)	-0.194(0.076)	-0.319(0.093)	-0.456(0.085)	0.377 *** (0.079)
Classification accuracy correctly predicated	73.5%	84.5%	82.0%	85.2%	71.6%	68.5%
Log-likelihood	-176.06	-122.74	-139.31	-119.24	-182.89	-194.62
LR Chi ²	(11) = 16.48	(11) = 37.47	(11) = 23.08	(11) = 37.88	(11) = 71.70	(11) = 43.80
Pseudo R ²	0.13	0.20	0.16	0.22	0.25	0.20

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Dedza district as the reference category

Table 5.6 cont'd. Marginal effects of binary logit regression models of farmers' direct involvement in performing common bean production activities.

Model	(7)	(8)	(9)	(10)	(11)	(12)
Variable	Marginal effects ($dE(y)/dx$) of farm household direct involvement in performing bean production activities					
	Harvesting	Transportation	Threshing	Winnowing	Sorting	Storage
Age of household head	-0.003 *(0.002)	-0.003(0.002)	-0.005 *(0.002)	-0.001(0.003)	-0.003(0.002)	-0.004(0.003)
Land holding size	-0.009(0.009)	0.004(0.013)	0.004(0.015)	-0.014(0.019)	0.019(0.015)	0.026 *(0.015)
Group membership	0.021(0.015)	-0.009(0.017)	0.011(0.020)	-0.025(0.025)	0.003(0.018)	0.004(0.019)
Bean farming experience	0.004 *(0.002)	0.006 *(0.003)	-0.005 *(0.003)	0.006 (0.004)	0.005 *(0.003)	-0.000(0.003)
Family size	0.007(0.008)	0.014(0.011)	-0.004(0.011)	-0.021(0.015)	-0.021 *(0.010)	-0.019 *(0.011)
Gender	0.101 *(0.052)	0.038(0.055)	0.015(0.063)	-0.228 *(0.082)	-0.046(0.057)	-0.038(0.062)
Literacy	-0.058(0.036)	-0.062(0.046)	-0.082(0.052)	-0.084(0.069)	-0.040(0.052)	-0.008(0.053)
Climate change awareness	-0.067(0.062)	0.025(0.075)	-0.030(0.085)	0.051(0.112)	0.057(0.086)	-0.013(0.087)
Chikwawa	-0.025(0.058)	-0.000(0.062)	-0.082(0.075)	-0.070(0.093)	0.111 *(0.059)	-0.017(0.075)
Nsanje	-0.093(0.059)	-0.051(0.061)	-0.054(0.074)	-0.195(0.091)	0.036(0.061)	-0.157 *(0.079)
Zomba	-0.088(0.058)	-0.009(0.059)	-0.077(0.073)	-0.192(0.094)	-0.051(0.063)	-0.100(0.076)
Classification accuracy correctly predicted	88.0%	84.9%	80.4%	66.9%	81.1%	79.8%
Log-likelihood	-105.56	-128.43	-152.04	-190.46	-142.02	-152.05
LR Chi ²	(11) = 21.36	(11) = 12.69	(11) = 12.07	(11) = 42.51	(11) = 20.62	(11) = 14.81
Pseudo R ²	0.21	0.14	0.14	0.20	0.15	0.15

Standard errors for marginal effects in parenthesis

*** Significance $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Dedza district as the reference category

5.4 Chapter summary

In this chapter, the factors affecting participation in decision-making, and direct involvement in common bean production activities in smallholder farming were determined by estimating binary logistic models. The results indicate that age of household head, land holding size, group membership, family size, gender, and climate change awareness significantly influence participation in decision-making on bean farming activities. This suggests that policies aimed at promoting the integration of young farmers in decision-making on production activities appear to be an important intervention area that can help maintain and strengthen the bean production chain.

The results also show statistical significant differences between males and females in their participation and direct involvement in common bean farming activities. The males dominate participation in decision-making of bean farming activities. However, depending on the nature of the activity, more females than males dominate involvement in selected few activities. Promoting gender inclusion at every node of bean production activity could facilitate participation in decision-making. Policies aimed at reducing the market prices of pesticides could promote participation in decision-making on increased acreage of common bean growing. Furthermore, age of household head, land holding size, bean farming experience, family size, gender, literacy, and climate change awareness have significant influence on direct involvement in performing bean farming activities. The results highlight the importance of nurturing, knowledge and information, and low labour demanding technologies. Therefore, promoting low energy requiring technologies in performing common bean activities could improve direct involvement by a range of different age groups and gender. Further, interventions intended to train new entrants in bean farming would maintain and improve smallholder bean farming. Having explored factors affecting decision-making and direct involvement in common bean production activities in smallholder farming, the next chapter presents the empirical results and discussions on understanding climate resilience using objective and subjective approaches.

CHAPTER 6. UNDERSTANDING SMALLHOLDER FARMERS' CLIMATE RESILIENCE USING OBJECTIVE AND SUBJECTIVE APPROACHES

6.1 Introduction

This chapter seeks to pursue Objective 3 of this study which explores the factors affecting smallholder farmers' resilience to climate variability and change using objective and subjective approaches. The chapter is structured as follows: Section 6.2 presents analytical framework and definition of variables. Section 6.3 discusses empirical findings on resilience to climate variability and change from an objective perspective in smallholder farming. Section 6.4 discusses subjective approaches to smallholder farmers' climate resilience. Finally, the summary of findings is presented in Section 6.5.

6.2 Analytical framework and definition of variables

6.2.1 Analytical framework

The concept of resilience is used in different fields of study, consequent to varied definitions. Resilience is a latent variable which makes its quantification problematic and complex. Recent work by the FAO resulted in the development of a framework meant to be used as a tool to measure households' resilience to food insecurity (FAO, 2010). However, due to its flexibility, the tool has been adapted to analyse issues in the context of unpredictable shocks and stresses to extreme weather and climate events (Tambo, 2016). In general, resilience implies the ability to respond to disturbances or change. This study adopts a definition by Tambo J, as the ability of the farm households to absorb and recover from climate induced shocks and stresses. Alinovi *et al.* (2010), Mekuyie *et al.* (2018), and Tambo (2016) used six components of resilience designed by the FAO to develop a farm household climate resilience index. The resilience components they include are assets (A), access to basic services (ABS), social safety nets (SSN), stability (S), adaptive capacity (AC), and income and food access (IFA). These six components of resilience are also latent variables, and therefore use observable indicators to quantitatively assess each component, thereby yielding a large set of variables. Therefore, reducing such a large set of variables into a small set while maintaining most information in the data set reduces the complexity.

The multi-variate technique was used to estimate the latent variables separately, through the use of principal component and factor analyses (Alinovi, Mane, et al., 2010). Principal component analysis (PCA) transforms a larger number of correlated variables into a smaller

number of uncorrelated variables called principal components (PCs). These PCs explain variability in the data, such that the first principal components account for much variability in the data set followed by a succeeding component. The principal components can be defined as a linear combination of optimally weighted observed variables (Maddala, 1992). In addition, the PCs are mathematical functions of all the original observed ratings and the first PCs explain the largest amount of variance in these ratings, followed by the second PC, and so on (Smith, 2002).

The selection of the principal components is based on the Kaiser (eigenvalue-one) criterion, which usually allows for retaining the correct number of components, particularly when fewer than 30 variables are being analysed, or when the analysis is based on more than 50 observations and the communality is greater than or equal to 0.60. The reason for choosing eigenvalue-one criterion is that each observed variable contributes to one unit of variance to the total variance in the data set, with those variables that display an eigenvalue greater than 1.00 accounting for a greater amount of variance. Such a component is worth being retained, but components with an eigenvalue less than 1.00 account for less variance, and are not retained (Mooi *et al.*, 2018). The PCs are estimated as linear functions of the original ratings as shown by:

$$PC = a_{i1}x_i + a_{i2}x_2 + \dots + a_{in}x_n \dots \dots \dots (6.1)$$

Where regression coefficients or weights ($a_{i1} \dots a_{in}$) are for observed variables $x_1 \dots x_n$, as used in creating PCs, and $X_1 \dots X_n$ are subject scores on the observed n .

Using the cross-section data, the climate resilience index was created to measure resilience of farm households against each component using the first PC and the standardized scores of the observed variables as represented by:

$$CRI_j = \frac{w_{ifa}IFA_j + w_{abs}ABS_j + w_{ssn}SSN_j + w_{ac}AC_j + w_sS_j}{w_{ifa} + w_{abs} + w_{ssn} + w_{ac} + w_s} \dots \dots \dots (6.2)$$

Where CRI_j is the climate resilience for district j , IFA , ABS , SSN , AC , and S are income and food access, access to basic services, social safety nets, adaptive capacity, and stability representing the resilience components, w is the number of indicators in each resilience component.

The regression analysis explaining resilience was run using the explanatory variables as shown in Table 4.1 in Chapter 4.

6.2.2 Estimation technique

6.2.2.1 Normal Linear Regression

This chapter employs normal linear regressions which assume that the observed dependent variable for the i^{th} observation y_i can be modelled as:

$$y_i = \beta_0 + \beta'x_i + e_i \dots \dots \dots (6.3)$$

where, as before, x_i is a column vector of explanatory variables, β' is a row vector of coefficients ($\beta_1, \beta_2, \beta_3 \dots \beta_K$) and β_0 is an intercept term and e_i is a random variable normally distributed with mean 0, and a variance that is also estimated. In these regressions it is assumed that the error term is not only normal, but has a constant variance (homoscedasticity), and the errors are independent of each other (serial independence). The normal linear regression is the simplest model within the class of models referred to as Generalised Linear Models (GLM). Within this model, the parameters represent the derivatives of the expected values of the dependent with respect to the regressors, or equivalently the expected change in the dependent variable given a one-unit change in the associated regressor. In this sense, it also represents “Marginal Effects”, as defined for the Binary and Ordered Logit Models. The normal linear regression models will be checked for heteroscedasticity using Breusch Pagan or Whites tests. Where these tests fail, robust standard errors will be used to correct for the heteroscedasticity. These tests will be executed using lp-mfx package in *Gretl* ([Gretl Team, 2021](#)). Heteroskedasticity is not desirable in a regression. Although it does not cause biases, it makes the coefficient estimates less precise, and hence, lower precision increases the likelihood that the coefficient estimates are farther from correct population. Further, heteroscedasticity tends to produce p-values lower than they should be, which increases the variance of the coefficient estimates that the OLS procedure does not detect.

6.2.2.2 Ordinal logistic regression model

This chapter uses ordinal logistic regression models to estimate farmers' perceptions of attributes of resilience to climate variability and change in smallholder farming. The attributes estimated include coping capacity, adaptive capacity, financial capacity, social capital, iterative learning, and information and knowledge. The details of model estimation are captured in Chapter 4, Section 4.2, Subsection 4.2.2, and Sub-subsection 4.2.2.2.

6.2.3 Definition of variables and summary statistics

6.2.3.1 Dependent variables

According to the work by [Alinovi et al. \(2010\)](#), income and food access (IFA) are an important and direct indicator connected to household resilience. In times of climate stresses and shocks, households with income and food access are likely to be more resilient. Enhancing farm households' efficiency of access to basic services (ABS) also improves resilience. Further, social safety nets (SSN) are key in helping reduce crises, especially among poor households. Poor households usually depend on assistance from charity organizations and non-governmental organizations (NGOs) among others. Hence, social safety nets are essential in improving farm households' resilience. Stability (S) is yet another important part of farm household resilience. This takes into account livelihood options in the face of losses due to climatic shocks, stresses and other shocks. Adaptive capacity (AC) is also an important dimension of household resilience as it shows the ability of the farm household to adapt and cope with the hazard and ensures continuity in performance of the systems' usual basic functions. [Table 6.1](#) gives the full description of the farm household resilience components and indicators.

Table 6. 1: Components and indicators of household resilience

Component	Indicator	Description	Unit
Income and food access	HFIAS	Household Food insecurity (HFIAS). Household response to nine food insecurity perception questions	Index,0-27
	Dietary diversity	Household dietary diversity score (HDDs), Household daily consumption of 12 food groups	Index 0-16
Access to basic services	Distance to water source	How far is it to the nearest water source?	Km
	Distance to market	How long is it to the nearest market?	Km
	Distance to health care	Distance to the nearest health care centre	Km
	Distance to all season road	Distance to the nearest all season road	Km
	Access to electricity	Farm household access to electricity	Dummy
	Access to a telephone	Farm household access to telephone	Dummy
Social safety nets	Access to credit	Farm household member receiving credit or cash in kind	MWK
	Assistance in cash or in kind	Household member assisted in cash or in kind	MWK/day/head
	Quality of assistance	Household satisfaction with the quality of assistance	Dummy
	Frequency of assistance	Number of times households received the assistance	Count
Stability	Assistance targeting	Household opinion on assistance targeting	Dummy
	Professional skills	Household members in possession of professional skills	Count
	Literacy level	Household head ability to read and write	Dummy
	Education level	How far has the household head gone with their education	Dummy
	Employment ratio	A ratio of employed household members to the household size	Ratio
	Job lost	Household members who have lost their jobs	Count
	Income variation	Household income stability	Dummy
	Assistance dependency	Ratio of monetary value of assistance to total income	Ratio
	Quality of assistance	Extent to which the assistance has improved	Dummy
	Medical care institutions	Number of institutions providing medical care	Count
Adaptive capacity	Quality of education	Extent to which quality of education has improved	Dummy
	Income sources	Number household income sources	Count
	Dependency ratio	Number of family members aged below 15 and above 64 to those aged 15-64	Ratio
	Print media warning messages	Household access of climate change early warnings messages through print media	Dummy
	Electronic messages	Household access to early warning message through electronic messages	Dummy
	Stakeholder engagement	Early warning message access through stakeholder engagement	Dummy
	Extension workers	Early warning message access through extension workers	Dummy
	Action to warning messages	Action taken by the household upon receiving early warning messages	Dummy
	Business ownership	Household local business ownership	Dummy

The dependent variables are constructed around the components of resilience. Resilience and its components are latent in nature and that direct measurement becomes problematic because they cannot be observed directly and depend on the observable data and combines it to make assumptions about the unobservable ([Papanicolas & McGuire, 2011](#)). Subsequent to this, its measurement is dependent on respective component indicators. Normally, latent variables form a larger set of data making it difficult and complex to analyze using regression models. To reduce this kind of large data set, the resilience components were subjected to principal component analysis where the first principal components was used to generate standardized regression factor scores. Further, the standardized scores were weighted to generate the composites of each component of resilience. Hence, these resilience components which include IFA, ABS, SSN, S, and AC form a set of dependent variables generated by compositing and regression factor score. These dependent variables were finally used in the general linear and ordinal regression models to explain climate resilience (Refer to [Table 6.1](#) for details about these dependent variables).

6.2.3.2 Independent variables

Details of independent variables used in this chapter are outlined in Chapter 4, Section 4.4 and Table 4.1.

6.3 Empirical results and discussions

This section presents and discusses empirical findings on household characteristics, components of resilience indicators, resilience by districts, and gender. Further, it examines factors influencing resilience of households to the changing climate. Finally, it explains objective and subjective approaches to understanding climate resilience in smallholder farming.

6.3.1 Descriptive statistics

6.3.1.1 Household characteristics

Summary statistics of farm households is discussed in Chapter 4, Section 4.4, and Table 4.1 show detailed description.

6.3.1.2 Climate resilience component indicators

This section discusses the component indicators of climate resilience as presented in Table 6.2.

6.3.1.2.1 Access to basic services

Looking at the first row of Table 6.2, the results show higher scores of distances to nearest water source in Dedza (0.617), and Zomba (0.201) while Nsanje (-0.330) and Chikwawa (-0.422) recorded lower scores. Similarly, in the second row, the results show positive scores of proximities to the main markets in Dedza (0.296), and Zomba (0.263). Regarding distance to the nearest health care centre (third row), only Dedza (0.356) shows a positive score. With respect to distance to an all-weather road, the results in the fourth row indicates a positive score in Nsanje (1.009). The fifth row of Table 6.2 shows positive scores on access to electricity in Nsanje (0.237), Chikwawa (0.032) and Zomba (0.012) districts, while Dedza district recorded negative scores. In terms of household access to telephone (the sixth row of Table 6.2), the results indicate positive scores in Nsanje (0.391) and Chikwawa (0.205). With respect to access to credit (the seventh row), the results show a positive score of 0.468 in Nsanje district, suggesting that households in Nsanje district have better access to credit than farm households in Chikwawa, Dedza and Zomba districts. The result further implies that farm households across the study sites move long distances to access a health facility, all weather roads, and have no access to credit. These make them less resilient to unpredictable extreme weather conditions as they may not be able to acquire the basic needs of life. These results are consistent

with the study by [Perez et al. \(2015\)](#), who asserts that resilient systems exhibit characteristics such as having wealth and access to some microfinance (credit), off-farm economic activities, i.e., migration (which can be accessed through all-weather roads), and availability of health facility among others. This finding is supported by the results from the focus group discussions as follows;

For us to be resilient to weather changes we rely on engaging ourselves into some small business. However, these businesses are affected by access to the main markets due to long distances, poor feeding roads into the all season roads and small capital due to lack of access to credits/loan. In times of extreme weather events our health statuses is greatly affected and yet we have no health facility in our proximity. It is not surprising that we are heavily hit by the impacts of the weather changes (MxFGDs). Males are better placed in terms of how they do their business activities as they mostly manage to walk or cycle long distances to sell the commodities unlike us females who have problems in walking such long distances (FFGDs). Though we sometimes manage to move/travel long distances to access the markets or health facilities, it is not easy, and affect us negatively and eventually we just give in (MFGDs).

6.3.1.2.2 Social safety nets

Considering social safety nets as a component of resilience, the results show a positive score of amounts of cash and in-kind assistance in Chikwawa district (0.151). Further, the score for quality of assistance (tenth row) is positive in Zomba district (0.311) while the scores for frequency of assistance (eleventh row) is positive in Zomba (0.016), Nsanje (0.219), and Chikwawa (0.033) districts. Finally, the score for assistance targeting is positive in Zomba district (0.126). These results suggest that farm households across the study sites received little, or no, support in the form of cash, and where received, the quality of assistance was poor with a positive frequency of assistance and moderate assistance targeting. This means that farmers in the study sites are less resilient to the changing climate as they receive little or no assistance in the form of cash, or in kind, in times climatic shocks and stress. Further, this means that most vulnerable and the poorest farm households fail to reach a minimum consumption level and are not able to cover basic needs. Furthermore, these farm households may fail to build their resilience to economic shocks through increased savings and investments in productive

assets and, therefore, frustrate long-term opportunities for productive inclusion ([Andrews et al., 2018](#)). This finding is supported by the results from the focus group discussions as follows;

In times of climatic shocks, we sometimes receive cash and in kind support to help sustain ourselves. However, this support do not take us long before we start suffering again because the amount of cash given is normally not enough, the quality of assistance is so low, the frequency of assistance is not stable and the assistance targeting is questionable (MxFGDs).

6.3.1.2.3 Stability

Looking at stability as a component of resilience, the results indicate positive scores of professionally skilled family members in Zomba (0.006), Dedza (0.079), and Chikwawa (0.055) districts. With respect to literacy and education level of household heads (15th and 16th rows of Table 6.2), the results show positive scores in Zomba (0.131 and 0.086 respectively), and in Chikwawa (0.088 and 0.072 respectively). Further, positive scores are recorded on employment ratio (0.213), household members who lost their jobs (0.135), and household income variation (0.012) in Zomba district. However, in Dedza district, the results show positive scores on household members who lost their jobs (0.015), household income variation (0.174), and assistance dependency. Furthermore, results show positive scores in Nsanje district on rating of quality of assistance (0.248), medical care institutions (0.152), and quality of education (0.014). Finally, positive scores are recorded in Chikwawa district (20th row) on assistance dependency (0.130), rating of quality of assistance (0.339), and quality of education (0.234). These results suggest that farm households in Zomba district are likely to be resilient to climate variability and change due to their high professionally skilled household members, higher literacy and education levels of household heads, and higher employment ratio among others. This result is consistent with the findings by [Perez et al. \(2015\)](#) who found that households with professionally skilled family members have options to survive in times of climatic shocks and stresses, hence, are more likely to recover from the effects of the hazards and, therefore, expected to be more resilient. Similarly, farm households in Chikwawa district are likely to be resilient to climate variability and change due to higher levels of professionally skilled household members, literacy and education levels, higher rating of quality of assistance and education. By contrast, the negative scores in some indicators of resilience suggest less likelihood of farm household resilience, and, hence, more likely to be affected by extreme

weather events as a result of climate change. The results from the focus group discussions contradict this finding as follows;

“If you go around in this area you will discover that no significant number of households have professional skilled labour, have attended higher education level, illiteracy levels are high, high unemployment ratio and high assistance dependency ratio among others. This is an indication that in time of climatic shocks it is likely that many households will be heavily affected and may not be resilient (MxFGDs). Females in this community are the ones which fall in the lowest point in terms of professional skilled labour, literacy levels and assistance dependency. It is therefore likely that the females are the most vulnerable to the effects of extreme weather events (FFGDs)”.

6.3.1.2.4 Adaptive capacity

With reference to adaptive capacity, the results show positive scores on access to information from extension workers (0.076), early warning action (0.161), household local business ownership (0.051) in Zomba district. Similarly, in rows 25-31 and third column of Table 6.2, the results show positive scores on income sources (0.176), dependency ratio (0.032), early warnings in print media (0.047), electronic media (0.117), direct stakeholder engagement (0.155), access to climate information from extension workers (0.113), drum beating, blowing whistles (0.192) in Nsanje district. Other positive scores are recorded in Dedza district on dependency ratio (0.024), early warning through extension workers (0.085), drum beating and blowing whistles (0.184), farmer to farmer (0.198), and early warning action (0.102). Further, positive scores are recorded on income sources (0.183), dependency ratio (0.096), early warning in print media (0.051), and electronic media (0.287) in Chikwawa district. These results suggest that farm households in Chikwawa, Nsanje and Dedza are dominated by family members aged below 15 and above 64, against household members between the ages of 15 to 64. Further, the results suggest that farm households in Zomba and Dedza did not have access to early warning messages through print media, such as newspapers, magazines, newsletters, leaflets, brochures, pamphlets, road banners, and billboards etc. Early warnings are important in areas which are dominated by climatic shocks and stresses. This helps the households be aware of what is anticipated, and possibly plan and prepare in advance ([Benchwick, 2016](#)). Overall, these results imply that most indicators of adaptive capacity across the study sites are

moderate except for dependence ratio, information by extension workers, farmer to farmer information sharing, and direct stakeholder engagement. Higher dependency ratio means a larger number of non-active labour force (individuals below the age of 15, and above 64), versus a smaller active labour force (between the ages of 15 and 64) (OECD, 2020). It is likely that in times of climatic shocks and stress, such population has less adaptive capacity and, therefore, less resilient to the shocks and stresses as a result of climate change. On the other hand, farm households across the study sites enjoyed services of extension workers on climate change information and related agricultural activities and, hence, have adaptive capacity. Finally, farm households across the study sites have less direct stakeholder engagement, and farmer to farmer intervention in times of climate shocks rendering them less adaptive and therefore less resilient to climate change.

6.3.1.2.5 Income and food access

Looking at IFA results show positive dietary diversity scores in Zomba (0.140), and Chikwawa (0.042). The other positive score is recorded on household food insecurity access score in Dedza (0.306). By contrast, negative dietary diversity scores are recorded in Nsanje (-0.011), and Dedza (-0.183). This result implies that, overall, farm households in Zomba (0.026) and Dedza (0.061) are food secure owing to relatively higher household food insecurity and dietary diversity scores and are likely to be more resilient to climate variability and change than farm households in Nsanje (-0.055) and Chikwawa (-0.045). This result is consistent with Perez *et al.* (2015), who asserts that a resilient system is food secure and has uncommon long hunger periods. This finding supports and contradicts the results from the focus groups as follows;

“Generally, our food security is for a short-term within the growing calendar. Very few households manage to be food secure throughout the year. Basically, our households have food to run for a period ranging from 4 to 6 months leaving the other half of the year without enough food. During which period we embark on to off-farm activities, migrating to other areas in search for casual work or where there are income generating activities/programmes to just have a little something to feed our families”.

Table 6. 2: Resilience indicator and component values for districts

Indicators	Zomba	Nsanje	Dedza	Chikwawa
Distance to nearest water source	0.201	-0.330	0.617	-0.422
Distance to nearest market	0.263	-0.386	0.296	-0.141
Distance to nearest health care centre	-0.022	-0.305	0.356	-0.003
Distance to all weather road	-0.793	1.009	-0.127	-0.113
Access to electricity	0.012	0.237	-0.306	0.032
Access to telephone	-0.010	0.391	-0.642	0.205
Access to credit (in cash or in kind)	-0.032	0.468	-0.424	-0.043
Access to basic services (ABS) Z-scores	-0.054	0.155	-0.033	-0.069
Amount of cash and in-kind assistance	-0.002	-0.068	-0.137	0.151
Quality of assistance	0.311	-0.303	-0.209	-0.256
Frequency of assistance	0.016	0.219	-0.500	0.033
Assistance targeting	0.126	-0.141	0.134	-0.210
Social safety nets (SSN) Z-scores	0.113	-0.073	-0.178	-0.070
Professionally skilled HH family members	0.006	-0.136	0.079	0.055
Literacy level of household head	0.131	-0.025	-0.209	0.088
Education level of household head	0.086	-0.088	-0.076	0.072
Employment ratio	0.213	-0.032	-0.147	-0.039
Household members who lost jobs	0.135	-0.037	0.015	-0.106
Household income variation	0.012	-0.050	0.174	-0.118
Assistance dependency	-0.068	-0.068	0.000	0.130
Rating of quality of assistance	-0.123	0.248	-0.516	0.339
Medical care institutions	-0.120	0.152	-0.008	-0.026
Quality of education	-0.085	0.014	-0.187	0.234
Stability(S) Z-scores	0.019	-0.002	-0.088	0.063
Income sources	-0.239	0.176	-0.143	0.183
Dependency ratio	-0.156	0.032	0.024	0.096
Early warnings print media	-0.042	0.047	-0.064	0.051
Electronic media	-0.031	0.117	-0.415	0.287
Direct stakeholder engagement	-0.053	0.155	-0.082	-0.026
Extension workers	0.076	0.113	0.085	-0.258
Drum beating, blowing whistles etc.	-0.277	0.192	0.184	-0.088
Farmer to farmer	-0.027	-0.019	0.198	-0.134
Early warning action	0.161	-0.213	0.102	-0.037
HH local business ownership	0.051	-0.174	-0.107	0.215
Adaptive capacity (AC) Z-scores	-0.054	0.043	-0.022	0.029
HFIAS	-0.087	-0.098	0.306	-0.132
DDS	0.140	-0.011	-0.183	0.042
Income and food access (IFA)Z-scores	0.026	-0.055	0.061	-0.045

6.3.1.3 Resilience components by districts

Referring to access to basic services as a component of resilience in Figure 6.1, results show a positive score of 0.155 in Nsanje district. By contrast, Zomba, Dedza and Chikwawa have negative score signifying less resilience. Due to the prevalence of climatic shocks in Nsanje district; organizations and financial institutions among others usually give credits to the households to help survive during the crisis period through running some small-scale businesses. In addition to this, there is improved access to telephones, electricity, and proximity to an all-season road.

In terms of social safety nets, the results show a positive score of 0.113 in Zomba district while Nsanje, Dedza and Chikwawa recorded negative scores. This is plausible because, compared to the districts which are prone to climatic shocks and stresses, Zomba has a low population which may result in improved access to the quality assistance, frequency of assistance and assistance targeting, thereby rendering it more resilient than other study districts.

Furthermore, on stability as a component of resilience, results indicate positive scores in Zomba district (0.019) and Chikwawa (0.063). By contrast, Nsanje and Dedza recorded negative scores of stability as a component of resilience. This is reasonable because from resilience component indicator scores, Zomba recorded positive scores in professionally skilled household members, household head literacy and education levels, and employment ratio. Similarly, Chikwawa recorded higher scores of assistance dependency, quality of assistance and quality of education making them more stable than the other study districts.

With reference to adaptive capacity, positive scores are recorded in Nsanje (0.043), and Chikwawa (0.029) districts. This is not surprising because these districts share agro-ecological zones, geographical boundaries, and economic activities.

Relating to income and food access, the results show positive scores in Dedza (0.061), and Zomba (0.026). This is conceivable because Dedza and Zomba are the least affected districts among the four with climatic shocks and stresses, therefore, their economic activities are less affected by climate change. Overall, these results imply that climate resilience components are different across geographical locations. Resilience of farm households in Zomba could be attributed to positive scores in social safety nets, stability, and income and food access, while their lower resilience rests on limited access to basic services and adaptive capacity. The direct opposite of this is Nsanje, where its resilience rests on the contribution of access to basic services and adaptive capacity, while its vulnerability is accelerated by social safety nets,

stability, and income and food access. Further, Dedza is highly vulnerable to the changing climate due to low access to basic services, social safety nets and stability; with only income and food access contributing to its resilience. Finally, Chikwawa's resilience is retarded by low access to basic services, social nets, and income and food access while dependent on stability and adaptive capacity for its resilience. Therefore, it is clear that proper targeting in all facets of resilience building is necessary to achieve resilience across geographical locations.

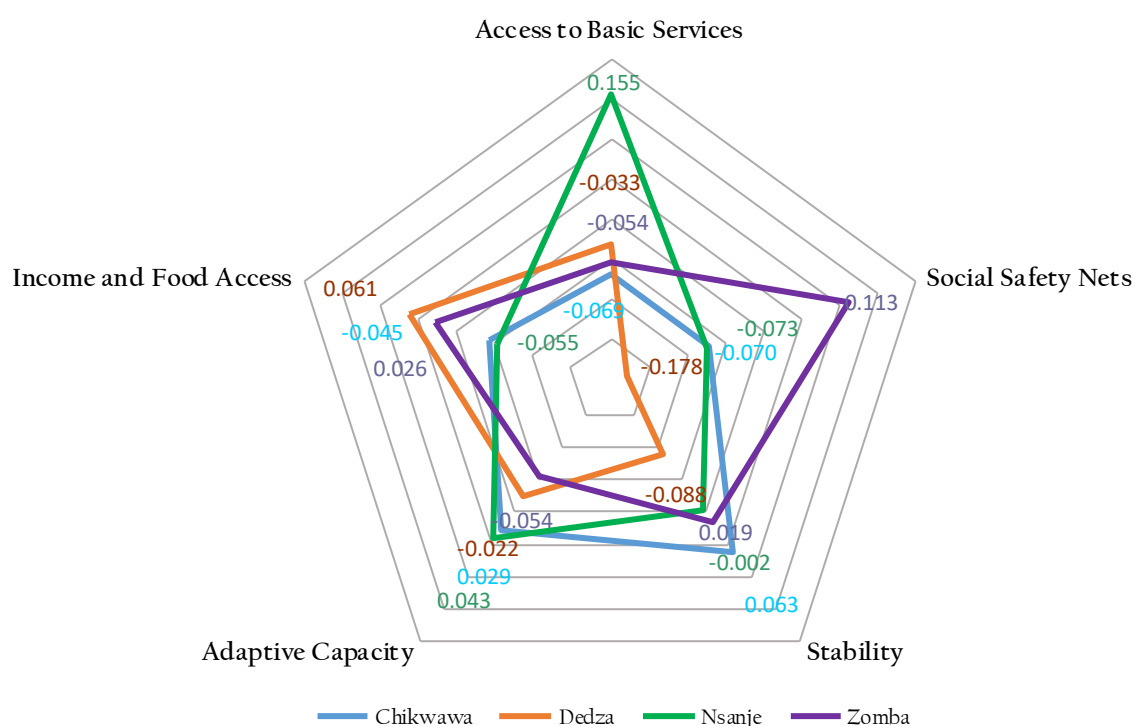


Figure 6. 1: Radar chart of resilience component by districts

In Figure 6.2, the results show positive weighted scores of components of climate resilience in Zomba (0.136), and Nsanje (0.172). By contrast, lower and negative scores are registered in Dedza (-0.003), and Chikwawa (-0.018). The results are reasonable because although Nsanje and Chikwawa share the same agricultural development division (ADD), some administrative sections fall in different agro-ecological zones. This has a bearing on how farm households in these different agro-ecological zones absorb and recover from the effects of climatic hazards. Further, the findings show better resilience in Nsanje, probably as a result of better access to basic services than any other district, and a higher score too in adaptive capacity. Another district that exhibited resilience is Zomba, probably due to lower frequencies or occurrences of climatic shocks and stress, and also, her resilience in a number of components, i.e., income and

food access, stability, and social safety nets. By contrast, Dedza and Chikwawa have overall negative scores implying less resilience.

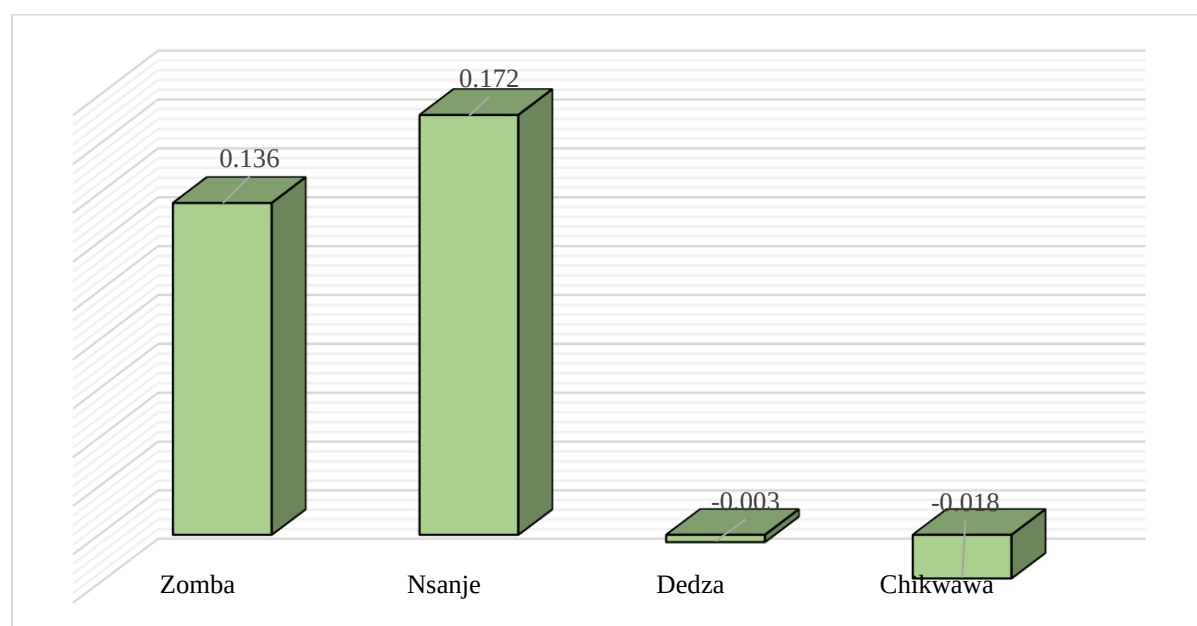


Figure 6. 2: Weighted resilience by districts

6.3.1.4 Resilience components by gender

Figure 6.4 presents resilience components by gender. Looking at male-headed households, the results show positive scores in access to basic services (0.009), stability (0.052), and adaptive capacity (0.082). By contrast, positive scores in female-headed households are recorded in income and food access (0.037), and social safety nets (0.020). This result suggests that male-headed households are more likely to be resilient than female-headed households, and that, in times of climatic shocks and stresses, females and children are in most cases the most susceptible groups in a community. Considering this fact, female-headed households are more often targeted for assistance if assistance targeting is based on the right criteria. Again, during crises, males migrate to other districts in search of income and food while females are at home looking after children and other household members (Hunter & David, 2009). This leaves females and other household members without food and income to survive and eventually result into engaging themselves in casual work or food for work programs. In so doing they generate little income to support their respective households to source food (Buechler, 2015). Further to these, during the FGD conducted with female participants, in all the study sites,

participants explained bitterly on how they survive through times of climatic shocks when their husbands have migrated in search for alternative sources of livelihood. They explained:

“While men (our husbands) are out in search of food and income, we (women) also engage ourselves into “dimba” crop production especially vegetables and other horticultural crops. Such kind of crop production help us to raise little income and food for the households to keep going day by day”.

The resilience in male-headed households is attributed to their access to basic services, stability, and adaptive capacity. This result is plausible because of patriarchy where men hold primary power and predominate in roles of political leadership, moral authority, social privilege and control of property. Hence, in most cases, men are in the forefront accessing markets, credits, information through telephones among others, thereby enjoying better access to basic services than women (Paul & Meena, 2016). In the same vein, males have more sources of income; greater access to climate early warning messages; engage in decision-making and taking action in response to early warnings received through different dissemination modes, i.e., print media, electronic media, direct stakeholder engagement, extension workers, farmer to farmers; and ownership of local businesses among others. This makes them more adaptable than females to climate variability and change and, hence, more resilient. Furthermore, males have been reported to have higher literacy levels than females where 53 percent of the females can read and write against 77 percent of men who can read and write. Again, the results further indicate that only 46 percent of females have attained primary education and higher against 74 percent of men who attained primary and higher education levels (Figure 6.3). This result implies that even the professional skills are skewed towards males, rendering them more stable/balanced than females to climate variability and change, hence, more resilient.

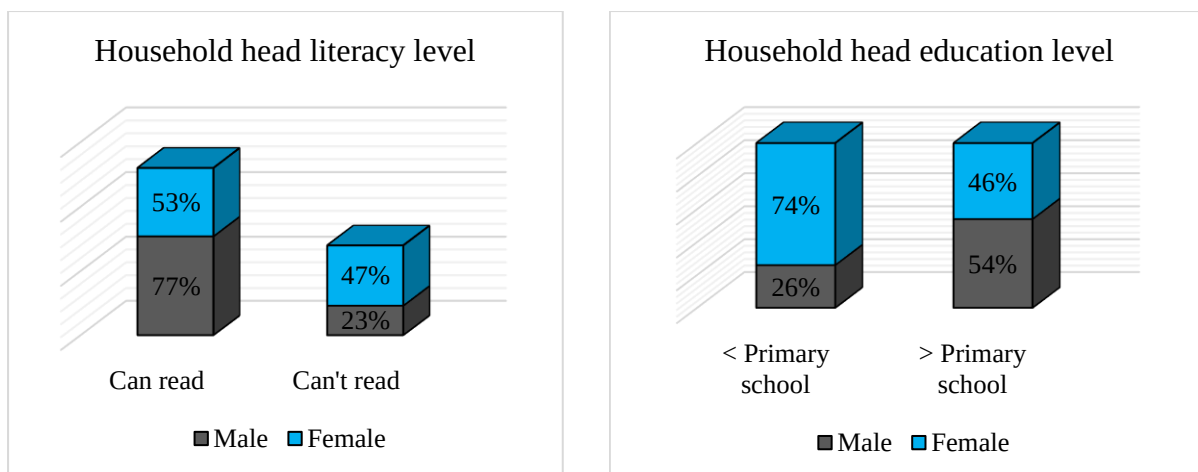


Figure 6. 3: Household head literacy and education levels

Note: n (Female) =83, and n (Males) =273

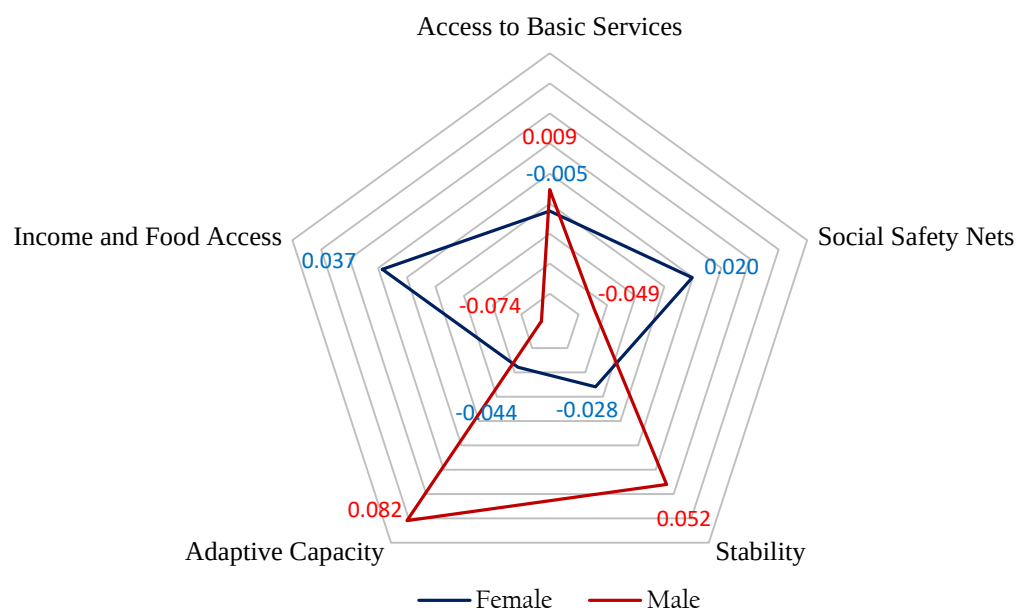


Figure 6. 4: Radar chart indicating resilience components by gender

6.3.2 Factors influencing resilience to climate variability and change in smallholder farming.

In examining and explaining climate resilience of the smallholder farmers, the criterion variables and their details are presented in Section 6.2.3.1 in Table 6.1 while explanatory variables are captured in Chapter 4, Section 4.4 and Table 4.1. The dependent variables were constructed through standardization of the components of resilience, i.e., ABS, S, AC, SSN, and IFA. These standardized component values were further weighted to devise continuous numbers representing variables in the case of weighted models. Further to this, a factor analysis was conducted to come up with the first principal factors which were used as dependent variables in regression of first principal factor scores (Refer to Questions 6.3.1 to 6.3.7 (ABS), 6.4.1 to 6.4.5 (SSN), 6.5.1 to 6.5.10 (S), 6.6.1 to 6.6.3a to g (AC), section 7 Q1a to 9 a (HFIAS), and Section 8 Q1-16 (HDDS) of the survey questionnaire in Appendix 1. The HFIAS and HDDS were weighted to devise IFA.

6.3.2.1 GLMs of weighted and first principal factor scores of access to basic services (ABS) as a component of climate resilience.

Table 6.3 presents the parameter estimates (coefficients) and standard errors of weighted, and first principal factor score of ABS. Referring to the first row of Table 6.3, for every additional year of household head age, the expected access to basic services decreases by a score of 0.021 in the REGR factor score_ ABS model given all the other variables in the model are constant and is significant. This result suggests a negative relationship between household head age and access to basic services. The result conforms to findings by [Barnes et al. \(2006\)](#) who assert that older people face a hindrance of exclusion, being unable to access certain basic services using usual forms of transport that provide basic provisions, many of which are fundamental to the quality of their lives.

The results further indicate that for every additional farm household group membership, the expected access to basic services decreases by a score of 0.131 in REGR factor score _ABS and is significant. This negative relationship suggests that increases in the farm household group membership improves and raises awareness of the importance of access to basic services. As these services are mostly provided unconditionally ranging from free, basic, public services, funded by taxes and provided by a government or public institution suffer competition among

the service users and negatively affect the access. These results are consistent with the work by [Hardin, \(1982\); and Olson \(1965\)](#) who found that the benefits of cooperation decrease with an increasing number of participants. On the other hand, [Oliver & Marwell \(1988\)](#) argued that benefits do not necessarily decrease as the group size increases and, in certain cases, they reason that cooperation might even increase with the size of the group. These two viewpoints have been mirrored by empirical, theoretical, and numerical works, with [Barcelo & Capraro \(2015\)](#) finding a negative effect, others finding a positive effect and yet others finding an ambiguous or non-significant effect ([Gautam, 2009](#)).

As farm household head literacy increases by one unit, the expected access to basic service score increases by 0.116 weighted_ABS model, and by 0.237 (REGR factor score_ABS model, given that all other predictor variables are constant, and are significant. This result suggests a positive relationship between literate farm household heads and access to basic services. This finding conforms to the work by [Kapur \(2016\)](#) and [UNESCO \(2006\)](#) who attest that literate individuals enjoy human, political, cultural, social and economic benefits of a society, and create opportunities for people to develop skills that will help them to provide for themselves and their families. These findings relate to the results from the focus group discussions as follows;

“Our grandparents normally have problems to access basic services as markets and health care centres due to long distances as they have mobility problems. This puts them in an awkward position as they are denied chances to access basic services which could improve their health status and livelihoods (MxFGDs). Again, individuals who are affiliated to different group have greater access to information as they learn different issues affecting everyday life and how they would improve livelihoods which include understanding the importance of public services. Many of these individuals normally seek to make proper use of basic services, which eventually result into increased demand of the same public good leaving others failing to access the same. Finally, individuals that are literate understand the importance of and benefits of accessing basic services (MFGDs). However, females are disadvantaged in accessing the basic services due to high literacy levels and limited affiliation to groups (FFGDs)”.

Table 6. 3: Parameter estimates of access to basic services as component of resilience using composited scores and first principal factor.

Variable	Weighted_ABS	REGR factor score _ABS Coefficients
Age of household head	−0.003(0.002)	−0.021*** (0.006)
Land holding size	−0.023(0.014)	−0.043(0.036)
Group membership	0.030(0.019)	−0.131** (0.052)
Bean farming experience	−0.000(0.002)	0.003(0.006)
Family size	0.005(0.011)	0.009(0.028)
Gender	−0.007(0.056)	−0.056(0.110)
Literacy	0.116** (0.050)	0.237* (0.126)
Climate change awareness	0.053(0.088)	0.062(0.211)
Districts	0.023(−0.000)	−0.068(0.056)
Constant	−0.018(0.145)	1.204(0.372)
<i>n</i>	317	317
R ²	0.05	0.11
Breusch Pagan Test	0.013	0.000

Standard errors in parentheses

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Where Breusch Pagan is significant, heteroskedasticity-robust standard errors are used.

6.3.2.2 GLMs of weighted and first principal factor of stability(S) as a component of climate resilience.

Looking at the [first row of Table 6.4](#), for every extra year of household head age, the expected stability score decreases by 0.005 and is significant. This suggests that increases in the age of household heads decreases their stability in the face of climate variability and change. This is conceivable because professional skills deteriorate with advances in age, employment ratio and assistance dependency ratio go up, and employment ratio, and household income stability go down.

For every additional year of bean farming experience, the expected household stability score decreases by 0.004 in the weighted _S model and is significant. This result suggests a negative relationship between farming experience and stability. This result follows the findings by [Kunzmann et al. \(2013\)](#) who found evidence for multidirectional age differences in affective

experience and suggest that the overall quality of affective experience may deteriorate in old age. This is not surprising because experience directly relates to age and, therefore, stability is expected to go down with increased experience.

Further, the expected household stability for male household heads is 0.118 more likely (REGR factor score_S model). This result suggests a positive relationship between male gender and stability. This is plausible because, from the descriptive statistics, it is clear that males occupy a larger proportion of literacy, professional skills, high employment ratio and low assistance dependency and, therefore, are more likely to be stable than females.

For literacy levels, the result indicates literate farm household heads are more likely to be stable than illiterate. This finding conforms to the finding by [Burriess \(2017\)](#), who found highest correlations between national literacy scores and human/national development.

Considering climate change awareness, households that are aware of climate change are 0.189 less likely to be stable (REGR factor score_S model). This suggests a negative relationship between climate change awareness and stability. This is possible because farm households can be aware of climate change when they have no professional skills, low levels of education, low employment ratio and high assistance dependency among others, therefore, rendering them less stable. These findings relate to the results from the focus group discussions as follows;

“Contribution of elderly individuals (people) to most livelihood activities normally go down, as functionality of their professional skills, education rigour and even physical effort deteriorate. It is clear that under normal circumstances we see old people just loafing within the homes waiting for most of the activities to be done for them, and these have direct effect on stability (MxFGDs). Due to high professional skills, high literacy levels, and high education levels in males, they are more stable than females (FFGDs)”.

Table 6. 4: Parameter estimates of stability as component of resilience using weighted scores and first principal factor.

Variable	Weighted_S	REGR factor score _S
	Coefficients	
Age of household head	0.002(0.002)	−0.005*(0.002)
Land holding size	−0.010(0.010)	−0.003(0.012)
Group membership	0.002(0.015)	0.064*** (0.015)
Bean farming experience	−0.004 *(0.002)	−0.002(0.003)
Family size	0.014(0.010)	0.008(0.013)
Gender	0.013(0.049)	0.118*(0.050)
Literacy	0.504*** (0.038)	1.959*** (0.049)
Climate change awareness	0.078(0.051)	−0.189** (0.063)
district	0.002(0.017)	0.006(0.020)
Constant	−0.545(0.111)	−1.255(0.149)
<i>n</i>	317	317
R ²	0.34	0.85
Breusch Pagan Test	0.000	0.006

Standard errors in parentheses

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Where Breusch Pagan is significant, heteroskedasticity-robust standard errors are used.

6.3.2.3 GLMs of weighted and first principal factor of adaptive capacity (AC) as a component of climate resilience

Referring to the first row of Table 6.5, for every additional year of household head age, the expected adaptive capacity score increases by 0.019 in REGR factor score_AC, and is significant. This suggests that as household heads advance in age, their chances of adaptive capacity increase through increased income sources, lower dependency ratio, and access to early warnings. Therefore, it is clear that increases in age of the household heads within threshold level increases their adaptive capacity.

For household land holding size, for every additional acre of household land holding size, the expected adaptive capacity score decreases by 0.033 in weighted_AC model and by 0.113 in REGR factor score_AC, and are significant. In any case, large land holding sizes do not necessarily translate to adaptive capacity because it depends on land use efficiency. There are

many people who have vast land yet go without enough food and income throughout the year. Due to lack of farming resources, many households usually rent out a larger proportion and farm on the smaller portion of their land. This is largely because, in the short-term, inefficient farmers are tempted to transfer the land to more efficient and progressive farmers ([Tesfay, 2020](#)).

Increases in household group membership by one unit increases the expected adaptive capacity score by 0.04.9 in weighted _AC model, and is significant. Households benefit from participating in different groups in terms of accessing information, extending social networks, social capital and financial capital among others ([Ahmed *et al.*, 2019](#)).

Regarding bean farming experience, for every additional year of household bean farming experience, the expected adaptive capacity score decreases by 0.010 in weighted _AC model, and by 0.036 in REGR factor score _AC model. The result suggests a negative relationship between bean farming experience and adaptive capacity. Contrary to expectations, this result suggests that experienced farm households sometimes do not cope with the change and consider their knowledge and experience enough to keep them moving forward when actually new challenges are coming in with new responses rendering them less adaptive and, therefore, not resilient to effect of climate variability and change.

With reference to literacy levels, the results show that increases in literacy levels in farm household heads by one unit, the expected adaptive capacity score increases by 0.102 in weighted _AC model, and by 0.372 in REGR factor score _AC, and are significant. This suggests that literate farm household heads are more likely than illiterate to have adaptive capacity. This is conceivable because literate farm household heads are more likely to access early warnings, i.e., through print and electronic media, and higher chances of diverse income sources and, therefore, more likely to be resilient than illiterate.

For household climate change awareness, increases in farm households that are climate aware by a unit, the expected adaptive capacity score increases by 0.282 in weighted _AC model, and 0.569 in REGR factor score _AC model, and are significant. This result suggests that climate aware household heads are more likely to have adaptive capacity to varying and changing

climate. This is attributable to their being informed about the anticipated changes of climate through print and electronic media, as well as other means of early warnings, i.e., extension workers, direct stakeholder engagement, drum beating and farmer to farmer among others, let alone are likely to be resilient. These findings relate to the results from the focus group discussions as follows;

Most of the individuals within the age group of active labour force are stable due to their involvement in a diverse income sources, direct engagement with the stakeholders, access to early warnings, and access to information through extension workers among others (MxFGDs). For individuals with larger land holding sizes and greater experience in bean farming, their stability is normally low because larger land holding sizes require more resources to produce reasonably which most smallholder farmers do not have. Again, highly experienced farmers are usually those that are outside the age bracket of active labour force which do not contribute significantly to livelihood activities and therefore are less stable (MxFGDs). Individuals who are literate and affiliated to groups and are climate change aware are normally stable (FFGDs, MFGDs and MxFGDs).

6.3.2.4 GLMs of weighted and first principal factor of income and food access (IFA) as a component of climate resilience.

The second row of Table 6.6 shows that for every additional acre of land holding, the expected income and food access score decreases by 4.250 in weighted_IFA model, and decreases by 4.223 in REGR factor score_IFA model given all the other variables in the model are constant and are significant. This result is plausible because, if used ineffectively or inefficiently, the increase in land holding size may not help improving the production and productivity so as to achieve higher returns from the produce and have enough to use for consumption. Hence, effective and efficient use of land is expected to contribute to improve household IFA.

As regard to household head group membership, with an increase in farm household group membership by one unit, the expected IFA score decreases by 0.4.765 in weighted_IFA model and decreases by a score of 4.888 in REGR factor score_IFA, and are significant. This suggests that irrespective of affiliation to several groups, IFA cannot be attained, perhaps because it is achieved through different ways, and the core objectives of the groups may not be relevant, leaving the household with no income and food access.

Table 6. 5: Parameter estimates of adaptive capacity as a component of resilience using weighted scores and first principal factor

Variable	Weighted_AC	REGR factor score _AC
	Coefficients	
Age of household head	0.003(0.002)	0.019*** (0.006)
Land holding size	−0.033** (0.014)	−0.113*** (0.028)
Group membership	0.049*** (0.019)	0.012(0.040)
Bean farming experience	−0.010*** (0.003)	−0.036*** (0.006)
Family size	0.019(0.012)	−0.014(0.026)
Gender	0.034(0.064)	−0.113(0.150)
Literacy	0.102* (0.055)	0.372*** (0.121)
Climate change awareness	0.282*** (0.088)	0.569*** (0.177)
district	−0.001(0.022)	−0.014(0.055)
Constant	−0.475(0.151)	−0.753(0.291)
<i>n</i>	317	317
R ²	0.12	0.17
Breusch Pagan Test	0.255	0.000

Standard errors in parentheses

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Where Breusch Pagan is significant, heteroskedasticity-robust standard errors are used.

As for literacy of household heads increases by one unit, the expected IFA score decreases by 11.677 weighted_IFA model, and decreases by 11.4 in REGR factor score_IFA. This result suggests a negative relationship between literacy, income and food access. Further, income and food access may be achievable through other means which may not require literacy. This finding contradicts to work by (Kapur, 2016) who attests positive relationship between literacy and economic benefits among others.

Finally, increases in the population of farm households by one unit across the study sites decrease the expected income and food access scores by 15.421 in weighted model, and by 15.272 in REGR factor score_IFA. This result suggests that increases in farm households' population results in a decrease in income and food access, possibly because of competing for

the same resources to use for income generation as food production. These results contradict the results from the focus group discussions as follows;

“Our fellow friend with larger land holding sizes enjoy high farm produce which normally translate into more income and food access, and those affiliated to more groups/associations and the literate have had income and food access. In the groups they participate, they have chances to access information and even chances to secure loan/credit facilities (MxFGDs)”.

Table 6. 6: Parameter estimates of income and food access as a component of resilience using weighted scores and first principal factor

Variable	Weighted_IFA	REGR factor score_IFA Coefficients
Age of household head	−0.113(0.273)	−0.128(0.274)
Land holding size	−4.250*** (1.593)	−4.223*** (1.593)
Group membership	−4.765** (2.103)	−4.888** (2.104)
Bean farming experience	−0.030(0.318)	−0.012 (0.318)
Family size	−0.481(1.314)	−0.442(1.314)
Gender	−2.126(7.165)	−2.083(7.165)
Literacy	−11.677* (6.121)	−11.400* (6.122)
Climate change awareness	11.762(9.820)	12.285(9.820)
District	−15.421*** (2.484)	−15.272*** (2.484)
Constant	9.216(16.813)	8.571(16.810)
<i>n</i>	317	316
<i>R</i> ²	0.20	0.20
Breusch Pagan Test	0.938	0.930

Standard errors in parentheses

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Where Breusch Pagan is significant, heteroskedasticity-robust standard errors are used.

6.3.2.5 GLMs of weighted and first principal factor of social safety nets (SSN) as a component of climate resilience

The second row of Table 6.7 shows that as household land holding size increases by one acre, the expected SSN score decreases by 2.690 in weighted_SSN and by 2.710 in REGR factor score_ SSN models. This result suggests that farm households with large acreage of land are less likely to access social safety nets because farm households with more land are considered wealthier and are often overlooked for assistance.

In terms of districts, farm households across the study sites are more likely to have social safety nets in times of climatic shocks and stresses. This is because most farm households in these study sites live below the poverty line, such that any simple shift in climate impacts greatly on their lives as their production too is solely for consumption and cannot support them throughout the year. In such circumstances, farm households depend on assistance from the government and/or non-governmental organizations. These findings relate to the results from the focus group discussions as follows;

“Very few individuals have large acreage of land in our communities, most of us have small land which means our production activities are restricted to those small pieces of land and this pose problems to achieve diversification and also higher crop or animal produce. Basically, for the individuals with large acreage of land and have capacity to use it effectively and efficiently, do not expect any social safety nets. However, the majority of us need social safety nets due to lack of enough cultivable land. Therefore in times of climatic shocks, we are heavily impacts and need assistance of some kind to help for survival (MxFGDs). Due to continuous occurrence and prevalence of climatic shocks such as floods, droughts and crop/animal pest and disease attacks in districts such as Zomba, Nsanje, and Chikwawa, the majority of the population rely on social safety nets for their survival (MFGDs, FFGDs and MxFGDs). Again, males mostly do own the land than females, making females to be more vulnerable than males to effects of changing weather and therefore seek more social safety nets (FFGDs)”.

Table 6. 7: Parameter estimates of SSN as a component of resilience using weighted scores and first principal factor

Variable	Weighted_SSN	REGR factor score _SSN
	Coefficients	
Age of household head	0.116(0.27)	0.123(0.271)
Land holding size	-2.710(1.58) *	-2.690(1.582) *
Group membership	-1.259(2.09)	-1.188(2.09)
Bean farming experience	-0.347(0.32)	-0.357(0.315)
Family size	-0.009(1.31)	-0.052(1.304)
Gender	-6.705(7.12)	-6.809(7.113)
Literacy	5.192(6.11)	5.499(6.077)
Climate change awareness	7.376(9.76)	7.209(9.748)
District	14.031(2.47) ***	14.064(2.466) ***
Constant	-97.974(16.715)	-98.213(16.691)
N	316	317
R ²	0.139	0.140
Breusch Pagan Test	0.753	0.732

Standard errors in parentheses

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Where Breusch Pagan is significant, heteroskedasticity-robust standard errors are used.

6.4 Subjective approach to climate resilience

6.4.1 Introduction

This section presents and discusses subjective approaches to understanding climate resilience in smallholder farming using descriptive and inferential statistics.

6.4.2 Descriptive statistics

Table 6.8 presents subjective attributes of climate resilience. The first row of Table 6.8 shows that approximately 56 percent of the respondents (23 percent strongly disagreed and 33 percent disagreed) did not support the assurance of coping capacity, and asserted that they would not be able to successfully cope and recover within six months from threats posed by extreme weather events as a result of climate variability and change. By contrast, about 41 percent (31 percent agreed and 10 percent strongly agreed) agreed that they would successfully cope and recover from the damage caused by extreme weather events within six months. This result suggests that a small majority of farm households in the study sites are exposed and cannot support themselves in the face of threats posed by climate variability and change, therefore, less resilient. However, a notable minority of farm households has the coping capacity to bounce back to normal functioning within a time space of six months, thus, are likely to be resilient to the changing climate. The results from disaggregated males and females on coping capacity as a subjective attribute of climate resilience show statistical insignificance (the first row of Table 6.9).

Considering adaptive capacity, approximately 63 percent of the respondents (19 percent strongly disagreed, and 44 percent disagree) refuted the assertion of adaptive capacity, and undeniably indicated they would not have the ability to successfully adapt to threats posed by climate change if the rate and intensity of extreme weather events were to increase significantly in the next five months. This result suggests that many farm households across the study sites do not have the ability to adjust to unpredictable weather events as a result of climate change, and, therefore, are likely to be less resilient. By contrast, a smaller percentage of the farm households across the study sites are likely to be resilient and have the ability to successfully adapt to climatic shocks and stress. The results from gender disaggregated attribute of climate resilience (the second row of Table 6.9) show that approximately 63 percent of females, and 65 percent of males do not have the adaptive capacity and are significant. The result suggests

that in times of climatic stresses/shocks, males are expected to slightly have lower capacity to adjust to the changes than females. This could be attributed to higher dependency ratio and income sources, such that in times of climate upsets, many dependents will be looking up to them for assistance while their incomes are equally affected by the varying and changing climate. This finding relates to the results from the focus group discussions as follows;

How climatic shocks come and destroy our properties, crops, and livestock, it would be a non-starter to believe that we can successfully stand/survive the effects of the shocks. We really don't have the capacity to do so as our production systems are mainly rain-fed, and are seasonal, hence, any disturbance at this level would mean recovery go beyond one season (MxFGDs). There have been seasons when crops in many of the fields in our communities were scotched by drought, swept away and submerged by floods, destroyed by pests and diseases, we were just left without anything to rely upon. Its recovery took almost one and half years in most of the farming households (FFGDs and MFGDs).

For financial capacity, approximately 60 percent of the respondents (21 percent strongly disagreed, and 39 percent disagreed) disputed the contention of financial capacity, assuredly indicating that they would not have access to sufficient financial resources to ensure full recovery from threats posed by climate variability and change. Interestingly, 36 percent (29 percent agreed and 7 percent) strongly agreed that they have the financial capacity and would be able to fully recover from the threats posed by heavy extreme weather as a result of climate variability and change. This means that most farm households do not have the financial resources to enable them to withstand the pressure of extreme weather events and recover, thus, less resilient. Conversely, a small percentage perceived they have the financial capacity to fully recover from the threats due to the changing climate. The results show statistical insignificance for male and female' financial capacity, which implies that both males and females face problems in securing financial resources (the third row of Table 6.9).

Relating to social capital, approximately 67 percent of the respondents (41 percent disagreed, and 26 percent strongly disagreed) were against the postulation of social capital and certainly indicated that they would not be able to draw on the support of family and friends to ensure full recovery from the threats posed by extreme weather events as a result of climate variability

and change. By contrast, about 30 percent (23 percent agreed and 7 percent strongly agreed) were in agreement and certainly indicated that their households would be able to draw on support from family and friends to fully recover from the threats posed in an event of extreme weather events, as a result of climate variability and change. This means that the majority of farm households across the study sites perceive they cannot rely on support from family and friend to recover from the shock as a result of climate change, whereas a small percentage perceive they can draw such support. The results on social capital disaggregated by gender show statistical insignificance, implying that even family and friends or relatives may equally be affected in times of climate stresses/shocks and that they may not be in a position to help out (the fourth row of Table 6.9).

Table 6. 8: Attributes of subjective measure of climate resilience

Resilience attribute	Strongly		Neither		Strongly	
	disagree	Disagree	agree nor	Agree	agree	
Coping capacity	82(23)	117(33)	7(2)	110(31)	36(10)	
Adaptive capacity	68(19)	157(44)	14(4)	96(27)	21(6)	
Financial capital	75(21)	139(39)	14(4)	103(29)	25(7)	
Social capital	93(26)	146(41)	7(2)	82(23)	25(7)	
Iterative learning	39(11)	110(31)	21(6)	153(43)	28(8)	
Knowledge & information	46(13)	82(23)	14(4)	157(44)	61(17)	

Note: $n = 356$. Percentages in parenthesis

In connection with iterative learning, about 42 percent of the respondents (11 percent strongly disagree, and 31 percent disagreed) dissented from the claim of iterative learning and unassailably point out that households' members have not learned to deal with past extreme weather events from within the households. By contrast, approximately 51 percent (43 percent agreed, and 8 percent strongly agreed) were supportive of the submission of iterative learning. This result suggests that a smaller percentage of family members perceive not to have benefited from within the household in the way they are expected to deal with the extreme weather events, while the larger proportion perceived they have really benefited from within the household. The results from a gender perspective indicate that males have benefited from within the farm households in learning on how to deal with future climate changes more than

females. This could be attributed to the fact that females are more often excluded from many discussions about issues due to cultural stereotypes in smallholder farming (the fifth row of Table 6.9). This finding related to the results from the focus group discussions as follows;

“It is difficult to use experience and learn from within our households on how to deal with past extreme weather events because these extreme weather events come in different faces in different years and therefore are unpredictable hence, preparation would not be easy (MFGDs). However, males benefit considerably from within the households on how to deal with the past extreme weather conditions because are normally they involved with open ended kind of conversation than females within the household (FFGDs)”.

Considering knowledge and information, about 36 percent of the respondents (13 percent strongly disagreed, and 23 percent disagreed) disputed the declaration of knowledge and information and clearly stipulated that their households would not have access to early warning information to ensure full preparation to the threats posed as a result of climate variability and change. By contrast, approximately 61 percent (44 percent agreed, and 17 percent strongly agreed) were in agreement and specified that they can access early warning information to be fully prepared to the threats posed by changing climate. This means the majority of farm household have access to early warning message to prepare for the threats in times of extreme weather events: a smaller group of farm households perceived they would not have adequate access. The results from gender disaggregated perspective on knowledge and information, as an attribute of climate resilience, show statistical significance, and that more males than female are expected to have access to early warning information, hence be prepared for threats posed as a result of climate change. This could be attributed to more male mobility and higher literacy levels than females, and hence have more access to information and knowledge (the sixth row of Table 6.9). This finding is supported by results from the focus group discussions as follows;

“Early warning information is nowadays available and packaged in all sorts of forms to suit different levels and categories of individuals ranging from print media, electronic media and some local forms.it is therefore not surprising to find many individuals are aware of the early warnings (MFGDs). However, while it looks that both gender have the same access to early warnings, males are normally at an advantage because of mobility factors and exposure to many trainings, and well their resourcefulness in sourcing the information (FFGDs)”.

Table 6. 9: Attributes of subjective measure of climate resilience disaggregated by gender

Attribute of climate resilience	Gender	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	<i>n</i>	Chi ²
Coping capacity	Female	62(26)	79(34)	5(2)	68(29)	21(9)	235	NS
	Male	18(15)	40(33)	3(3)	43(36)	17(14)	121	
Adaptive capacity	Female	54(23)	93(40)	12(5)	63(29)	13(6)	235	S
	Male	13(11)	65(54)	2(2)	34(28)	7(6)	121	
Financial capital	Female	55(23)	95(40)	8(3)	61(26)	16(7)	235	NS
	Male	18(15)	45(37)	5(4)	43(36)	10(8)	121	
Social capital	Female	63(27)	100(43)	6(3)	50(21)	16(7)	235	NS
	Male	29(24)	49(41)	2(2)	32(26)	9(7)	121	
Iterative learning	Female	28(12)	79(34)	18(8)	97(41)	13(6)	235	S
	Male	7(6)	35(29)	4(3)	58(48)	17(14)	121	
Knowledge & information	Female	36(15)	60(26)	12(5)	91(39)	36(15)	235	S
	Male	8(7)	22(18)	1(1)	65(54)	25(21)	121	

Note: In parenthesis are percentages; NS-not significant; S-significant at 0.005.

6.4.3 Ordinal regressions of attributes of subjective approach to understanding farm households' climate resilience

As distinct from the objective approach to understanding climate resilience which normally uses social economic factors, subjective approaches use attitudes of farm households to extreme events as a result of climate variability and change. The response variables of subjective measures of climate resilience have been constructed from an iteration of questions that solicit attitudes and perceptions of farm households. The set of six statements with opinion likert responses (strongly disagree, disagree, neutral, agree, and strongly agree) were used to capture resilience which each represent a dependent variable. These six statements include: 1) If heavy threats posed by extreme weather events are to occur in your area tomorrow, what would be your comment if it is said that your household would be able to successfully cope with the threats, fully recover from the damage caused within six months? (Coping capacity); 2) If the rate and intensity of extreme weather events are to increase significantly in the next five years, what would you comment to 'your household would have the ability to successfully adapt to threats posed'? (Adaptive capacity probing transformative capacity); 3) If heavy extreme weather events are to occur in your area tomorrow, would your household have access to sufficient financial resources to ensure that you fully recover from the threats posed?

(Financial capacity); 4) If heavy extreme weather events are to occur in your area tomorrow, would your household be able to draw on the support of family and friends to ensure that you fully recover from the threats posed? (Social capital); 5) Has your household learned considerably from you (household head) about the way you have dealt with past extreme weather events (this knowledge is crucial in successfully dealing with future events)? (Iterative learning); and 6) If heavy extreme weather events are to occur in your area tomorrow, would your household have access to early warning information to ensure that you are fully prepared for the threats posed? (Knowledge and information). (Refer to Questions 5.1 to 5.6 of the survey questionnaire in Appendix 1.) The expected changes in these dependent variables (DVs) are measured based on unit change of independent variables (IVs) captured in Table 4.1 in Section 4.4 expressed as marginal effects.

6.4.3.1 Marginal effects of ordinal logistic results of attribute of subjective approach to understanding of climate resilience in smallholder farming

Table 6.10 presents the marginal effects and standard errors of ordinal logistic regression models of the attributes of a subjective approach to understanding climate resilience. With reference to the second row of Table 6.10, results show that as farm household land holding size increases by one acre, the expected coping capacity score decreases by 0.12 on average, given all the other variables in the model are constant, and is significant. This result suggests a negative relationship between household land holding size and coping capacity, and disputes the assurance of coping capacity in times of heavy threats by extreme weather events and that farm households with larger land holding size would not be able to successfully cope with threats, fully recover from damage caused within six months. This is plausible because, due to the changing climate, smallholder farmers are practising various strategies, some having economic benefits driven by cost reductions over time rather than increased yields. This has a negative impact on coping capacity as, normally, smallholder farmers are discouraged and focus on short-run gains thereby making it an overriding factor limiting the use of coping strategies on their farm land (Corbeels *et al.*, 2014). This finding supports the result from the focus group discussions on how do individual farmers with larger acreage of land fair with climatic changes compared to those holding small pieces of land as follows;

“Extreme weather events are not selective in terms of how the shocks destroy our properties, crops and livestock, worse still those with large acreage suffer a big blow because they large land planted to crops or a bigger number of herd being damaged means a great loss. Sometimes, those with small pieces of land feel less (MxFGDs)”.

For every additional farm household group membership, the expected coping score decreases by 0.17, iterative learning by 0.11, knowledge and information by 0.15. This suggests negative relationships between group/association memberships, and coping capacity, iterative learning and knowledge and information. This implies that increased affiliation to group/association membership does not signify coping capacity, considerable learning from within the household which is crucial in successfully dealing with future events, or knowledge and information. This is interesting because, normally, an increase in the number of groups of membership by the households would be expected to increase the possibility of acquiring of knowledge and information of various agricultural activities. This finding differs considerably with the results from the focus group discussions as follows;

“For those of us who are affiliated to groups/clubs/associations are exposed to different issues ranging from production, climate change adaptation, and management among others. This make us more knowlegeable and learning considerable that we share the information and kbowledge gained to family members and others beyond through direct contact or demonstrations through our performance in our crop fields and/or how we raise our livestock(MFGDs)”.

In relation to adaptive capacity, probing transformative capacity⁹, the results indicate that as household bean farming experience increases by a year, the expected adaptive capacity, probing transformative capacity and social capital scores decrease by 0.02. This suggests that, in smallholder farming, additional years spent in bean farming do not guarantee the farm households’ ability to successfully adapt to threats posed (adaptive capacity), and support from

⁹ Transformative capacity is the capacity to make intentional change to stop or reduce the causes of risk, vulnerability, poverty, and inequality, and ensure the more equitable sharing of risk so it is not unfairly borne by people living in poverty or suffering from discrimination or marginalisation ([Oxfam, 2017](#)).

family and friends to ensure full recovery from the threats posed. The results from the focus group discussion support this finding as follows;

Unpredictability of extreme weather events has neutralised the importance of our experience, because we can plan or prepare against weather changes in one way, eventually we discover the change is beyond our preparation, this has really challenged us to greater extend and that have seen our crops, livestock and property being damage and destroyed while we made prior advances in the preparation of the extreme weather events.

Referring to literacy level, the expected coping capacity score of literate farm household heads decreases by 0.63, and financial capacity by 0.50. This suggests that literate farm households are less likely to have coping capacity to extreme weather events, and less likely to have access to sufficient resources to ensure they fully recover from threats posed due the changing climate. This result is interesting because literate farm household heads, normally, would be expected to have a variety of benefits to help them stand the damage that may be posed by the extreme weather events due the changing climate. This finding supports the results from the focus group discussions as follows;

In principle those of us who are literate, the expectation is that we are able to cope favourably with extreme weather events and have financial capacity but the reality is that extreme weather events may sometimes not affect individuals directly while indirectly cause a great damage. For instance, one could have financial muscle to survive the effects of extreme weather events but may fail to secure the resources they need due to damage cause to the sources. Hence literate individual may well know about the extreme weather event but still fall into the effect trap as they may not have ways of sustaining themselves (MxFGDs).

Looking at farm household head climate change awareness, farm household heads who are aware of climate change are less likely to have access to early warning information to ensure full preparation for threats posed. This is another interesting result, because normally farm households that are climate change aware are expected to have access to early warning information.

In terms of the study districts, compared to Dedza district, the expected coping capacity in Chikwawa district decreases by a score of 0.27 and by 0.49 for knowledge and information, and are significant. These results imply that farm households in Dedza district are less likely to have coping capacity and climate change information and knowledge. Finally, in regard to the tenth row of Table 6.10, the financial capacity of farm households in Nsanje are expected to increase by a score of 0.50, iterative learning by 0.14, knowledge and information by 0.53, while referring to the eleventh row, the expected coping capacity score increases by 1.18, adaptive capacity by 0.42, financial capacity by 0.81, iterative learning by 0.27, and information and knowledge by 0.83 in Zomba district and are significant. Generally, this result implies that geographical locations have both negative or positive influence on attributes of subjective resilience in smallholder farming

Table 6. 10: Marginal effects of ordinal logistic regressions of attributes of subjective approach to understanding climate change resilience.

Variables	Coping capacity	Adaptive capacity	Financial capacity	Social capital	Iterative learning	Knowledge & information
	Marginal effects ($dE(y)/dx$)					
Age of household head	-0.00(0.01)	0.01(0.01)	0.00(0.01)	0.01(0.01)	0.00(0.01)	-0.00(0.01)
Land holding size	-0.12 *(0.06)	-0.07(0.05)	-0.07(0.06)	0.01(0.05)	-0.05(0.06)	0.00(0.05)
Group membership	-0.17 *(0.08)	-0.01(0.07)	-0.11(0.07)	0.04(0.06)	-0.12 *(0.08)	-0.15 * (0.08)
Bean farming experience	-0.01(0.01)	-0.02 **(0.01)	-0.01(0.01)	-0.02 **(0.01)	-0.01(0.01)	-0.00(0.01)
Family size	0.00(0.04)	-0.00(0.05)	0.01(0.04)	-0.05(0.04)	-0.01(0.05)	-0.01(0.04)
Gender	0.08(0.24)	0.01(0.23)	0.02(0.23)	0.16(0.21)	-0.02(0.26)	-0.09(0.24)
Literacy	-0.63 *** (0.20)	-0.27(0.19)	-0.50 ** (0.19)	-0.24(0.17)	0.16(0.23)	-0.21(0.21)
Climate change awareness	-0.24(0.31)	-0.16(0.28)	-0.33(0.29)	-0.24(0.25)	-0.49(0.36)	-0.62 * (0.33)
Chikwawa	-0.27 *** (0.25)	-0.19(0.24)	-0.30(0.24)	-0.09(0.22)	-0.06(0.29)	-0.49 * (0.27)
Nsanje	0.82(0.28)	0.10(0.25)	0.50 * (0.27)	0.14(0.23)	0.70 *** (0.27)	0.53 * (0.29)
Zomba	1.18 *** (0.30)	0.42 * (0.26)	0.81 *** (0.27)	0.27(0.24)	1.08 *** (0.30)	0.83 *** (0.33)
Classification accuracy correctly predicted	41.6%	44.5%	41.6%	40.7%	47.3%	48.9%
Log-Likelihood	-406.27	-407.11	-405.99	-409.81	-387.22	-406.69
LR Chi ²	(11) = 124.92	(11) = 92.00	(11) = 111.20	(11) = 88.54	(11) = 136.83	(11) = 115.11
Pseudo R ²	0.18	0.13	0.16	0.13	0.19	0.17

Standard errors for the average marginal effects at mean in parenthesis, whereas significance denotes the deviation for zero in the coefficient of the latent variable in a regression

*** Significant $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$

Dedza district as the reference

6.5 Chapter summary

This chapter investigated factors affecting resilience to climate variability and change through the use of objective and subjective approaches in smallholder farming in Malawi using Linear Regression Models and Ordinal Logistic Regression models (OLR). Regarding the objective approach to understanding climate resilience, the results reveal that age of household head, land holding size, group membership, bean farming experience, literacy and climate change awareness have influence on resilience through one or more of its components. These results suggest that policies aimed at reducing barriers to access to basic services to both literate and illiterate farm households through investments in reducing distances to clean water sources, markets, health care centres, all weather roads, and access to credits appear to be an important intervention area that can improve household resilience to climate change. Furthermore, promoting efficient use of land through: improved agricultural technologies; associations/farmers groups that focus on income generating activities; and advocacy on agricultural production activities to supplement farmers experience while ensuring gender integration also appear to be important interventions that can influence resilience. From the subjective perspective of understanding climate resilience, the results reveal that land holding size, group membership, bean farming experience, climate change awareness and literacy have significant influence on attributes of climate resilience. The results suggest the importance of attitude on how individuals manifest resilience. Policy interventions aimed at improving quality of assistance, assistance targeting, reduced dependency ratio and assistance dependence could improve resilience in smallholder farming. Finally, promoting location specific interventions based on need appear to be important intervention area due to differences in spatial vulnerability to extreme events as a result of the changing climate. The next chapter presents discussions and conclusions drawn from all the empirical findings, the key policy recommendations and areas of further research.

CHAPTER 7. CONCLUSIONS

7.1 Introduction

This study set forth to look into resilience to varying and changing climate in smallholder farming in Malawi. Based on the data from four research sites, the study established smallholder farmers' perceptions of climate variability and change and compared this with meteorological data over time. Furthermore, the study attempted to explore the factors affecting smallholder farmers' decision-making, and direct involvement in performing bean farming activities at farm household level in the face of climate variability and change. Finally, the study aimed to objectively and subjectively understand resilience to climate variability and change in smallholder farming. This chapter will recap the goal and objectives of the study and outline the main findings in line with the three objectives of the study¹⁰. Further, the chapter will reflect on the conceptual framework and methodology used in this study. The chapter is concluded by exploring the implications of the study for theory, policy and practice and areas of further research.

7.2 Recapping the purposes of the study

Evident from its high share in the Gross National Product (GDP), the agricultural sector remains a mainstay of economic growth and development in most countries in Sub-Saharan Africa (SSA), including Malawi. Prioritisation of the agricultural sector in development agenda reflects its important role in contributing to food security, provision of livelihood for multitudes of small-scale producers that constitute approximately 80 percent of all farms in SSA. Although the agricultural sector's prospects heavily influence economic development in most countries in SSA, it is not without challenges. Due to its reliance on rain-fed agricultural systems, SSA has been described as the most susceptible region to the influences of climate variability and change on account of its high level of sensitivity to weather and climate variables, such as temperature, precipitation, and light and extreme events. Forecasts by the Inter-governmental panel on climate change (IPCC) suggest decreased crop yields in most tropical and sub-tropical regions due to alterations in temperature and precipitation patterns as a result of the changing climate, thereby adversely impacting on agricultural sectors and worsening the pervasiveness of hunger in developing countries. In addition to these direct climatic impacts, climate change will further worsen the existing vulnerabilities of smallholder farmers as a result of poverty,

¹⁰ See Chapter 1, Section 1.3: Study Aims, Research Objectives and Research Questions

sensitivity of their geographical locations, high dependence on natural resources and limited capacity to adopt new livelihood strategies. Circumventing these impacts of climate variability, changes in agriculture require an understanding of smallholder farmers' resilience to climate variability and change. It is extensively acknowledged that farmers' resilience to climate variability and change is driven by how they perceive the changing climate, and later take action to deal with climate-induced risks and opportunities. Such kind of actions by smallholder farmers are reflected in their production activity decisions at farm level in the face of the changing climate.

Considering that smallholder farmers are known to possess indigenous knowledge to cope during extreme events, and have considerable experience in dealing with climate variability, the unprecedented and sustained levels of variability associated with long-term climate change are outside the realm of what traditional coping strategies are able to manage. This calls for an understanding to unpack their perceptions, knowledge and impacts of the changing climate therein. However, very few studies have empirically investigated smallholder farmers' perceptions to climate change, and decision-making in production activity in the face of climate variability and change in Malawi. Furthermore, to date, no empirical study has sought to understand climate resilience using both objective and subjective approaches in smallholder farming in Malawi. This study, therefore, aims to address these knowledge gaps and explore relevant policy implications for improved food self-sufficiency, security, and income through resilience to the changing and varying climate in smallholder farming. To achieve this, the study was guided by the following specific objectives:

- (i) Understand perceptions, knowledge and impacts of climate variability and change in smallholder farming.
- (ii) Understand smallholder farmers' decision-making and direct involvement in bean production activities at household level in the face of climate change.
- (iii) Understand climate resilience using objective and subjective approaches in smallholder farming.

These objectives were addressed by research questions which articulate the conceptual framework. Table 7.1 presents research questions and where they are addressed and/or discussed in this thesis.

Table 7. 1: Research questions and where they are addressed within the thesis structure

Research question	Chapter and section where discussed
1.1 How do farmers perceive climate variability and change in smallholder farming?	Chapter 4, Section 4.6.2: Farmers' perception of climate variability and change Chapter 4, Section 4.6.2.6: Gendered general perceptions of climate variability and change
1.2 How does climate variability and change affect common bean production in smallholder farming?	Chapter 4, Section 4.6.2.3: Perceived effects of climatic shocks or stresses Chapter 4, Section 4.6.2.5: Perceived effects of climate change on crops, humans and livestock
1.3 How are decisions on the use of adaptation strategies made in smallholder farming?	Chapter 4, Section 4.6.2.4: Farm household decision on the use of adaptation strategies
1.4 Are men and women affected, perceive and respond the same to climate variability and change?	Chapter 4, Section 4.6.2.6: Gendered general perceptions of climate variability and change
2.1 What affects participation in decision-making on bean farming activities in smallholder farming?	Chapter 5, Section 5.3.2: Household participation in decision-making on common bean farming activities
2.2 Do males and females have equal participation in decision-making in bean farming activities?	Chapter 5, Section 5.3.1: Participation in decision-making in common bean production activities in smallholder farming in the face of climate change.
2.3 What influences direct involvement in undertaking bean farming activities in smallholder farming?	Chapter 5, Section 5.3.4: Household direct involvement in performing bean farming activities
2.4 Do males and females engage in performing bean farming activities?	Chapter 5, Section 5.3.3: Farm household involvement in performing common bean production activities.
3.1 What influences resilience to climate variability and change in smallholder farming?	Chapter 6, Section 6.3.2: Factors influencing resilience: an objective approach Chapter 6, Section 6.3.3: Subjective approach in understanding resilience
3.2 How resilient are farmers across geographical locations?	Chapter 6, Section 6.3.2: Factors influencing resilience: an objective approach Chapter 6, Section 6.3.3: Subjective approach in understanding resilience
3.3 What relationships exist between objective and subjective approaches to understanding resilience to climate variability and change?	Chapter 6, Section 6.5: Chapter Summary

7.3 Recapping the conceptual framework

Whereas the study's conceptual framework proved vigorous in the construction of the research methodology and as an instrument for the analysis of the data that was collected, drawing on the research process and analysis of findings of the study, the researcher suggests the following adjustments to the conceptual framework for purposes of greater clarity and simplification of the analysis process:

- Placing more emphasis on the fact that decisions of every particular bean farming activity in this era of climate variability and change is influenced by perceptions and attitude of farmers.
- Enacting inclusivity of gender at every node of common bean farming activity would improve the performance of the system.
- There is a need for clear clarification of farmers' perceptions of climate variability and change in relation to systems exposure, sensitivity, and adaptive capacity and how these translate into systems' resilience.
- There is also a need to include the farm household demographic characteristics into the conceptual framework considering their vital roles in shaping systems' perceptions of climate variability and change.
- Whilst it is recognized that farm households' asset base is one of the key indicators of resilience, data collected on this was so confusing that it did not make any sense and, hence, was dropped from the analysis. This was attributed to the fact that study subjects anticipated that researcher was lobbying for identification of farmers who may need support and, hence, they denied ownership of every asset, except where the researcher directly asked about an asset that was before them.
- Increasing the connectedness of gender into the conceptual framework, i.e., linking it to disturbances (natural hazards, conflict, insecurity, and food shortages), capacity to deal with disturbances, and reaction to disturbances (survive, cope, learn and transform). The reverse arrows indicated no inclusion of gender to signify the expected negative response of the system to climate variability and change and, hence, vulnerable or less resilient.

These adjustments are demonstrated in the modified conceptual framework in Figure 7.1 below:

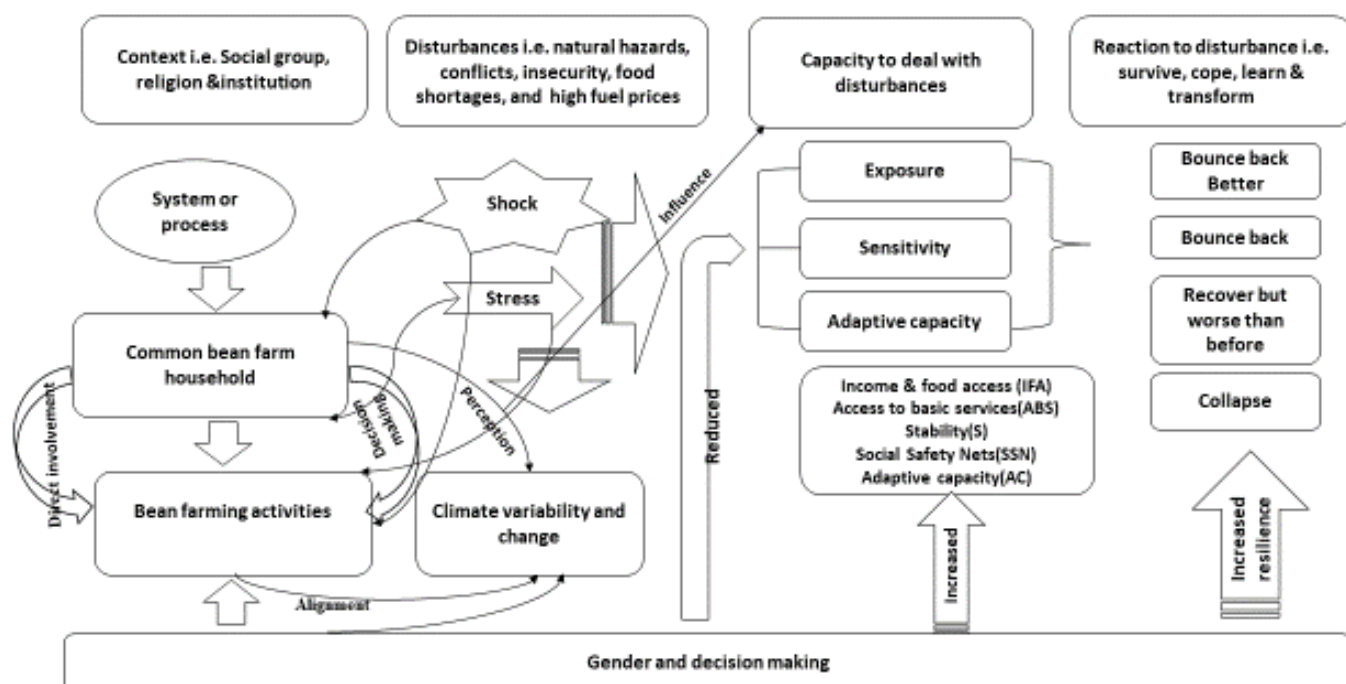


Figure 7. 1: Revisited conceptual framework

This study's findings relate to the conceptual framework in the following facets;

- ❖ The findings show a clear importance of aligning decision-making on bean farming activities in face of climate variability and change.
- ❖ The findings show that perceptions influence how the bean farming system operates in the face of climate change.
- ❖ The conceptual framework show the importance of gender in undertaking common bean activities and how the system is expected to improve its performance.
- ❖ The conceptual framework recognises that resilience from the objective point of view is attained through the improvement of socio-economic and environmental variables to reduce exposure, sensitivity and increase adaptive capacity.
- ❖ The findings explicitly indicate that resilience is not only captured through an objective approach, and that the conceptual framework captures the importance of self-assessment in how resilient the farmers are to climate variability and change (subjective approach).

- ❖ However, the conceptual framework fails to capture the exact factors that influence perceptions, and resilience which the results are exhibiting.

7.4 Re-examining the methodology

Studying farmers' resilience of climate variability and change is procedurally challenging. Owing to its complex and dynamic nature, some researchers have suggested that it is not something that can be meaningfully quantified or measured (Walker & Salt, 2012). However, several relevant tools sought to assess resilience at different scales have been developed and applied across a wide range of sectors, including agriculture (Frazier *et al.*, 2013). Similarly, effective studying of farmers' perceptions of climate variability and change is methodologically demanding (Simelton *et al.*, 2011). Measuring resilience is complex, due to its latent nature it cannot be measured directly, instead requiring indicators which can directly be observed, and are sometimes latent too. The estimation of such variables is possible using multivariate analysis, i.e., principal component analysis and factor analysis (Alinovi, D'Errico, *et al.*, 2010). A mixture of methods was adopted using a diversity of participatory approaches for data collection: a farm household questionnaire (main tool); focus group discussions; trend analysis; pair-wise ranking; in-depth interviews with development and extension actors; key informant interviews (KII), and in-depth interviews with individual farmers. As a result of this re-examination of the methodological approach, three themes emerged, set out below.

Firstly, the research approach: during the exploratory study it became clear that administering all the designed tools was unviable, as it could lead to collecting huge amount of data which could be problematic and too much to handle for one study. Hence, KII, in-depth interviews with individual farmers and development practitioners and extension actors were not conducted. The missing content in those participatory approaches was incorporated into the structured schedule (questionnaire). This provided a comprehensive data collection protocol and enabled generation of the expected data and beyond.

Secondly, the research process: it was identified that meteorological time series data could not be captured using the multiple tools devised for the study. Secondary data was collected later after most other data had been collected but was a bit scant in some instances. Data collected from the meteorological department had a lot of missing data. Considering this, a trend analysis of events was conducted to establish how climate change variables have changed over time.

This produced some interesting insights about gender, in terms of how such changes or trends affect different genders, and their response.

Lastly, the group activities: in some instances, it was so confusing finding so many gathered to participate in the research when the researcher only needed 6-8 participants for a group discussion of any sort, be it focus group discussions (FGDs), trend analysis, or pair-wise ranking. However, despite the difficulty of managing larger groups, it provided a fertile niche for interesting insights which helped considerably in capturing hidden information which could not be explored using the other tools.

7.5 Main findings and contribution to knowledge

This section briefly revisits and discusses the main findings from the study which are organized according to the three major thematic areas of research, based on the research objectives¹¹.

7.5.1 Perceptions, knowledge, and effects of climate change in smallholder farming

The empirical results show the significance of bean farming experience, implying that more years of farming increases understanding of the trends of rainfall characteristics, therefore, as the years of bean farming increases, the less likely farmers will perceive late main rainfall ending. The results suggest that over years of farming, farmers have been experiencing early main rainfall ending. Furthermore, farmers' membership to groups was found to have a positive influence on perception of the amount of the main rainfall season. Again, literate farm households are more positive and are also aware of fluctuated trends of onsets of main rainfall season. The perceptions of climate variability and change differ across geographical locations as a result of different climatic and environmental conditions. Therefore, farm households located in drought prone areas, i.e., Chikwawa and Nsanje, were found to be less likely to perceive the early onset of the main rainfall season. Again, farmers in Nsanje were found to be less likely to perceive increased temperature, whereas farmers in Zomba were found to be more likely to perceive increased temperature over the past 10 years.

The results reveal that farm households with larger acreage of land, literate, and aware of climate variability and change anticipate future increases in the main rainfall seasons. Experienced farmers in bean growing were found to anticipate decreases in temperature while literate farmers were found to be less likely to anticipate future decreases in temperature, and

¹¹ See Chapter 1, Section 1.3: Study Aims, Research Objectives and Research Questions

farmers that are aware of climate change showed uncertainty in future changes of temperature. Farm households in Chikwawa district anticipate future increases of temperature. Older household heads perceive mixed production changes over the past 10 years ranging from increased, decreased and varied crop production, this suggests that older farmers have passed through different events of time with different production outputs.

Furthermore, older farm household heads have varied perceptions of the level of effects of drought or dry spells on bean production, ranging from extremely severe, very severe, severe and significant probably because of different levels of droughts or dry spells in different spaces of time. Farm households in Nsanje district perceive extremely severe effects of flood/or too much rain on bean production especially those producing under rain-fed production systems. Bean production in Nsanje, Chikwawa and Zomba is less affected by pests and diseases due to winter production which normally occurs during a time of unfavourable conditions for pests and diseases. One benefit of individual farmers' group membership is the reduced impact of hailstorms on bean production. Again, farmers perceive increased yield per acre of common beans with decreased level of effect of hailstorms.

Regarding farm household decision-making on use of adaptation strategies to climate variability and change, results reveal that decisions on the use of adaptation strategies at farm household level are normally done by either household heads or spouses and, where these are not well informed of the strategies, powers to make decisions are transferred to others within the household depending on demographic traits. In terms of who makes the decision on the use of adaptation strategies between males and females, the results show that males are at the pole of decision-making than females on the use adaptation strategies to climate variability and change.

The results further reveal that women's chances of contributing to the choices of the right adaptation strategies to climate variability and change decrease with an increase in family size. Again, there are still disparities around how climate change affects men and women, access to climate change information, user friendliness of adaptation strategies (technologies), and inclusion of women in food security issues. Group membership helps recognize the importance of women's involvement in adaptation strategy choices to improve on crop yields. In a patriarchal society, as the male household age advances, decisions in dealing with climate change are made by spouses.

7.5.2 Decision-making and direct involvement in bean production activities in smallholder farming in the face of the changing climate

The empirical results reveal that participation in decision-making in threshing and winnowing of common beans decreases with increased age of the household head possibly because these activities are production activities that require physical effort. Increase in the household land holding size negatively influences farmers' participation in decision-making on pest and disease sprays, probably because a larger area of land planted to crops may attract more pesticides and/or insecticides which may require more money to purchase which many smallholder farmers cannot afford due to financial constraints. Household group membership negatively influences participation in decision-making on fertilizer application to common beans. Fertilizer application is one of the non-traditional bean farming practices in most developing countries, including Malawi, where fertilizer is one of the most expensive farming inputs. Hence, despite benefiting from information about the importance of fertilizer application from different groups of membership, participation in such decisions became problematic as cash is required for purchase. The results also revealed a positive relation between family size and participation in decision-making on fertilizer application. This may be because the larger family size entails more family labour. Participation in decision-making on fertilizer application has a negative relationship with farmers' awareness to climate change. Furthermore, the results revealed that women are less likely to participate in making decisions across the bean production activities.

The estimation results revealed that direct involvement in common bean production activities is influenced by a number of factors including age of the household head, land holding size, bean farming experience, literacy levels, family size, climate change awareness, and gender.

The results further reveal that increased family size results into increased labour force, hence, increased direct involvement in bean farming activities. This suggests that increases in labour force reduces the amount of work to be done per individual household member per unit time. Critical bean farming activities, e.g., fertilizer application is undertaken by experienced farm household heads. Increased land holding size attracts direct involvement of all family or household members in production activities. This suggests that increased land holding size implies larger acreage of cultivation which calls for more labour force in every activity of the production system. In female-headed households, female heads normally undertake activities that relate to the ownership of, or control of, resources and direct involvement of family members is normally sought where involvement requires physical efforts. Illiterate farm

household heads use their indigenous knowledge to do some bean farming activities. With respect to males and females, males dominate participation in decision-making on bean farming activities. However, there are no significant differences between males and females in some bean farming activities on how they directly engage. Depending on the nature of the activity, females dominate selected few activities.

7.5.3 Understanding climate resilience through objective and subjective approaches

7.5.3.1 Objective approach

The empirical results reveal that older farm households are expected to have lower ABS, probably due to mobility problems; this has the potential to render them less resilient to the varying and changing climate. Farm households in Nsanje and Chikwawa have higher ABS and, hence, are expected to be more resilient to the changing climate. Illiterate farm households are more likely to be less resilient to climate change due their lower levels of stability. Larger sized farm households are expected to be more stable than small sized farm households, hence, more resilient of the changing climate. In the context of gender, results reveal that women have lower levels of stability compared to men and, hence, are expected to be less resilient to the changing climate. Again, farm household membership to groups increases their stability and the chances of being resilient to climate change. The negative significant effect of land holding size suggests that the larger the land holding size, the less the adaptive capacity and, hence, less resilient to climate change. Household group membership increases the adaptive capacity possibly due to access to information, extended social networks, and social and financial capital among others. Individual farm households' adaptive capacity can be improved with increased bean productivity. Again, more experienced farmers are expected to be less resilient to the changing climate due to their reliance on indigenous knowledge which may not stand the realm of current challenges as a result of the changing climate. Also, farmers that are not aware of climate change have lower adaptive capacity and, hence, less resilient to climate change. Individual farmers' income and food access is negatively related to land holding size, group membership, and bean farming experience. This suggests that increased land holding size, affiliation to a number of groups and vast experience of bean farming does not guarantee income and food access, let alone resilience. Further to these, experienced farm households have higher social safety nets, hence, are expected to be more resilient to the varying and changing climate.

7.5.3.2 Subjective approach

The empirical results reveal that group membership and land holding size do not explain coping capacity to the threat posed as a result of the changing climate, and that female farmers and illiterate farm households are more likely to be affected by the threats posed by extreme weather and would be unable to successfully cope with and recover. Experience in bean farming does not guarantee the ability of farm households to adapt to the threats posed by the changing climate and that illiterate farm households may not successfully adapt to higher rates and intensity of extreme weather events as a result of the changing climate. Increased land holding size does not signify access to sufficient financial resources although illiterate farm households are less likely to access financial resources to recover fully from the threats posed by extreme weather events. Increase in family size makes it more difficult to get social support, i.e., from family and friends, to recover from the effects of the changing climate. Family size, group membership, gender, literacy and climate awareness have a negative relation to the iterative learning. The results further reveal that despite group membership of the farm household, farmers still lack knowledge and access to early warning information. Female farmers and farm households that are unaware of the changing climate are less likely to have access to early warning information to fully prepare for the climatic threats.

In terms of geographical areas, individual farm households in Chikwawa and Nsanje have greater capacity to cope with threats posed by the changing climate compared to Dedza and Zomba. While in terms of adaptive capacity, the results reveal that Nsanje has the capacity to adapt to climate threats, better access to financial resources, and higher levels of iterative learning than Chikwawa, Zomba and Dedza. Finally, Chikwawa has more knowledge and access to early warning information than Nsanje, Zomba and Dedza.

7.6 Summary of the key findings as per the research questions

This section sets out the research findings of the study based on the research questions as outlined per study objective in Section 1.3 of Chapter one.

Objective 1

Research question (i): How do smallholder farmers perceive climate variability and change, and how does it compare with the meteorological data? The results from the binary and ordinal logistic regression models showed significance in seasonal characteristics of rainfall and that farmers perceived early stops, increased amount of rainfall, and unpredictability of the onset of the main rainfall season. These results are consistent with the descriptive perception findings by [Ogalleh et al. \(2012\)](#), [Legesse et al. \(2012\)](#), and [Kashaigili et al. \(2014\)](#) who found that the majority of the farmers indisputably perceived increases in temperature, late onsets of rain and decreases in amount of main rainfall seasons. However, on the other hand, the results disagrees with the findings by [Hageback et al. \(2005\)](#) on relating farmers perception of temperature with historical meteorological data. Owing to the comparative perception findings, this study finds that farmers perceived temperature increases, are not aligned with historical meteorological data while the amount of main rainfall season is aligned with the historical meteorological data.

With respect to the future anticipation of rainfall and temperature, the ordinal logistic model revealed that individual farmers perceive changes in the future amount of main rainfall seasons, and future temperature. These perceptions were found to be influenced by farm household group membership, bean farming experience, literacy levels, family size, and climate change awareness. These results are consistent with the findings by [Gbetibouo \(2009b\)](#) who found that a range of some socio-economic and environmental variables influence farmers perception of climate variability and change.

Research question (ii): How do climate variability and change affect smallholder common bean farmers? As revealed by the ordinal logistic regression model, the results suggest that climate induced risk, i.e., pest and diseases, and heat wave, negatively affect crop production including common beans. The results show no significant effects of droughts/dry spells and floods/too much rain, probably because of farmers' dependency on irrigated or residual moisture production. While farmers that depend on rain-fed production systems particularly suffer the effects of droughts or dry spells, floods or too much rain, and hailstorms to some degree. The results further indicate that farmers' perceived impacts of climate variability and change are negatively driven by farm household group membership and literacy level. This is

consistent with the findings by [Mandleni & Anim \(2011\)](#) who found a negative relationship between impact of climate change and education and noted that it is actually the adverse impact of climate change that keeps the person aware rather than education and group membership.

Research question (iii): How are decisions on the use of adaptation strategies made in smallholder farming? The results from the binary logistic models revealed that decision-making on the use of the adaptation strategies (i.e., irrigation, crop rotation, chemical fertilizers, use of drought tolerant varieties, changes in planting times, and non-farm activities) are influenced by group membership and bean farming experience. This result relates to the findings by [Mamba \(2016\)](#) who argued that experience is directly related to age such that older farmers are more experience due long time accumulation of indigenous knowledge and more likely perceived to make the decisions of the use of adaptation strategies based on experience.

Research question (iv) Do men and women perceive and respond the same to climate variability and change? The results from ordinal logistic regression model revealed that men and women perceive and respond differently to climate variability and change due to disparities in the chances given to women in exercising their knowledge to deal with effects as a result of the changing climate, user unfriendliness, and exclusion from choosing adaptation strategies to climate change. The result further indicates that these are influenced by household group membership, land holding size, bean farming experience, and gender. These results are consistent with the findings by [Tunde \(2011\)](#) who found that men and women do have different perceptions of climate variability and change because of differences in access to climate change information. However, these results contradicts the findings by [Legesse et al. \(2012\)](#) who found no statistical significant difference between men and women in how they perceive climate variability and change. In addition to this, [Denton \(2002b\)](#) indicated that the incidents associated with climate change are oblivious to boundaries and therefore expected to affect the lives of women and men equally.

Objective 2

Research question (i): What affects participation in decision-making in bean production activities in smallholder farming? The results from binary logit models revealed that participation in bean production activities is influenced by age of the household head, family size, and gender. These results are consistent with the findings by [Lastarria-Cornhiel, \(2006\)](#), [Enete & Amusa \(2010b\)](#) who found that due lack of land ownership of women makes them difficult to take part in farm-related decisions, and traditionally, men dominate decision making on both household matters and crop management. On the other hand, age of the household head

and family size affect participation in decision probably because as the age and family size increases there is more division of labour within the household rendering shifts in the participation in decision making.

Research question (ii): Do males and females have equal participation in decision-making in bean farming activities? The results show that males dominate the participation in decision-making in bean farming activities.

Research question (iii): What influences direct involvement in undertaking bean farming activities in smallholder farming? The results from the binary logit models revealed that direct involvement in performing bean production activities in smallholder farming is influenced by bean farming experience and gender.

Research question (iv): Do males and females have equal direct involvement in performing bean farming activities? The results show some statistical significant differences in some few activities where females dominate. However, most of the bean farming activities showed no significant differences. This is consistent with the findings by [FAO \(1995\)](#); [ILO \(2009\)](#) that noted that women provide most of labour, and managing a large part of farming activities on a daily basis. However, these contradicts the findings by [Nakazi et al. \(2017\)](#) who found that there are no bean farming activities that are limited to women.

Objective 3

Research question (i): What factors influence resilience to climate variability and change in smallholder farming? The results from regression model showed that age of the household head, literacy levels, household group membership, family size, land holding size, and bean farming experience influence resilience to climate variability and change from an objective approach perspective. Further, from the ordinal logit models the results showed that land holding size, household group membership, literacy levels and bean farming experience influence farmers' resilience to climate change from a subjective point of view. These results are consistent with the findings by [Herrman et al. \(2011\)](#) who found that resilience has determinants from multiple levels.

Research question (ii): How resilient are farmers across geographical locations in smallholder farming? The results from regressions and ordered logit models showed that farmers have different resilience levels or capacities to climate variability and change across geographical locations. This is consistent with the findings by [Southwick et al. \(2014\)](#) who found that resilience in one community may differ from those of another community.

7.7 Implications for theory, policy and practice

A number of implications for climate resilience theory, policy and practice were raised from this study. This section will discuss the implications of the findings from this study for theory, policy and practice.

7.7.1 Implication for theory

Integration of vulnerability and resilience approaches

This study found that resilience thinking needs to assimilate the concept of vulnerability although they are rooted in different epistemological traditions in natural and social sciences. When striving to achieve individual or systems' resilience, it is clear that vulnerability assessments with regards to exposure, sensitivity and adaptive capacity is reasonable. This means building systems' resilience entails devising means of counteracting vulnerabilities. The complementarities between vulnerability and resilience have the potential of improving the understanding of smallholder farmers' resilience to climate variability and change. The points of overlap/convergence between resilience and vulnerability are more numerous and more fundamental than divergence and can contribute on the common front, strengthening the ability to solve real world problems (Miller *et al.*, 2010). The study further found that smallholder farmers perceive their farming activities and livelihoods are extremely affected by a wide range of climatic and non-climatic shocks and stresses. However, in some components of assessing resilience, the findings shows positive resilience. This suggests that while people, communities, agencies and infrastructure may all be exposed to hazards and risks, that is be vulnerable, they may equally possess qualities that reduce vulnerability. This can be called resilience and it is not just the absence of vulnerability. Rather it is the capacity, in the first place, to prevent or mitigate losses and then, secondly, if damage does occur to maintain normal living conditions as far as possible, and thirdly to manage recovery from the impact. There are a number factors that support individuals, families and communities to minimise the consequences of disasters in terms of supporting preparedness activities as well as supporting and sustaining recovery activities. Identifying and assessing those positive factors possessed or shared by individuals, families, groups, communities and agencies which support resilience gives emergency planners and managers the opportunity to further develop resilience to increase the 'disaster resistance' of the population (Buckle *et al.*, 2000).

Resilience versus development or poverty reduction

The findings from this study highlight that a reasonable proportion of smallholder farmers were resilient to climate variability and change in the context of access to basic services, social safety nets which normally fall under the domain/characteristics of public goods, while being trapped in poverty as they have low income and food access (assessed through household food insecurity access, and household dietary diversity scores), low stability and adaptive capacity. This explicitly recognises that resilience is not the same as development, and that poverty reduction is of great importance as strengthening resilience sometimes results in the system bouncing back to undesirable states, e.g., where populations live in poverty. [Béné et al. \(2014\)](#), in a review of an article of resilience, poverty and development, it is posited that resilience is becoming a very influential integrating concept that put different disciplines and communities of practice together. As such it could offer a useful platform to enable the bridge between emergency and development. Nonetheless, resilience is not a panacea and should not be presented as the new catch-all for development. There are considerable issues related to the use of resilience both conceptually and empirically, in particular, in relation to development and poverty alleviation. There is therefore a need to improve the understanding about what resilience means precisely, especially in respect of the existence of ‘good’ and ‘bad’ resilience, before endorsing it too widely. It is urged that the politics of resilience need to be recognised and integrated more clearly into the current discussions. Otherwise, if applied uncritically, a resilience-based approach might end up leading us towards abandoning interest in the poor(est) for the sake of strengthening community or even (eco) system-level resilience. On the basis of this analysis, it seems that practitioners and development agencies—if they really want resilience to become a true instrument of poverty alleviation—should step back, consider the objectives of their interventions and then assess more carefully and rigorously how resilience can support (or hinder) these objectives

Resilience foster learning, flexibility, participation and empowerment

The findings from this study support the importance of learning, flexibility, participation and empowerment in a resilience system. Issues of farm household group membership are key to improve on the resilience of individuals or communities, because, within groups, smallholder farmers often have significant expertise when it comes to managing their own farm systems ([Chambers & Ghildyal, 1984](#)). Additionally, there is a potential to learn from others and, where possible, their experience and knowledge should be integrated and enhanced to strengthen the resilience of the farming systems ([Dixon & Stringer, 2015](#)). Drawing from the work of

(Lambrechts, 2020), participation to groups empowers and orient individuals towards dealing with complexity and post-truth characteristics, and prepare to be critical, make informed decisions, understand, and deal with challenges. Resilience is oriented towards dealing with uncertainty, adversity and disruptions. The role of groups is then to prepare individuals to cope with uncertainty and adversity, by introducing uncertainty in groups, embracing it and discussing it. Systems resilience can be strengthened through integrating processes of learning and social learning into both the development and application of resilience frameworks and tools (Tschakert & Dietrich, 2010).

Power and politics

The findings from this study highlight that decision-making on farming activities in the face of climate variability and change are dictated by power and politics within the farm household. This means that such decisions may have impacts on the farm household's response to climate variability and change and subsequently affect their resilience. Therefore, considerations of power and social justice should be considered, and conceptualizations of resilience should capture the capacity for change. The findings from this study further highlight household heads being dominant decision-making units within the smallholder farming systems. This has the capacity to hinder other household decision making units to contribute positively resilience. Capacities at an individual or farm level should also be considered (Dixon & Stringer, 2015). The farm household decision-making process is complex, as many factors and a multifaceted environment influences farmers in their decision-making approach. Bradford (1990) as cited in (Von Ketteler, 2018) describes the farming environment as complex and uncertain due to aspects of various origin, such as being economically or environmentally successful and of uncertain outer influences, like weather or political frameworks. Furthermore, farmers can be influenced by their surrounding and the information given by the community (Ibid.). Another essential influence in the decision-making of a farmer are lessons learned from the past and possible recovery processes (Ibid.). Therefore, better integration of issues of power, change and transformation into tools and frameworks is of greater addition to the any systems' resilience.

Spatial, temporal dynamics and trade-offs

Findings from this study indicate that the study sites have different contextual factors that shape resilience to climate variability and change. This means that measures or approaches to achieve resilience have to focus on specific systems, limited to geographical area, individuals,

household or farm level. However, this result need to be taken with caution considering that this study was conducted in only four districts of rural Malawi and that generalization at this level require a more sound empirical research backing. Furthermore, most of the existing tools and frameworks fail to capture the temporal and spatial dynamics of social ecological systems (SES) and do not adequately address or incorporate the spatial and temporal trade-offs that may be required in dealing with climate variability and change ([Dixon & Stringer, 2015](#)) .

Perception and climate resilience

The findings from this study highlight that a good proportion of smallholder farmers that perceived climate is changing, used adaptation strategies and resilience mechanisms to deal with climate variability and change. The findings further highlight the positive relationship between perceptions of the changing climate and climate resilience. The study by [Ranjan & Abenayake, \(2014\)](#), on community's perception of disaster resilience concept, emphasized on the fact that the process of resilience building require recognition of local perception in order that deep insights of local realities of unique community personalities, culture that makes differences in the levels of individual's resilience are brought forward rather than merely following globally fixed models and frameworks. The findings further suggest that perception influences adaptation and acts as a pathway to climate resilience. It should also be pointed out that a certain percentage of the smallholder farmers that perceived the climate is changing chose not to use the adaptation strategies and resilience mechanisms. This results suggest that there are also other factors that influence directly or indirectly the resilience pathways.

7.7.2 Implication for policy, and practice

Farmers' perception of the changing climate in smallholder farming emanates from the way they think and behave in relation to the climate change variables, i.e., precipitation and temperature etc., particularly in the SSA where farmers depend on rain-fed agriculture. The role of perception of climate variables such as seasonal characteristics of rainfall, and temperature in influencing how farmers deal with climate induced risks and opportunities suggests that providing better access to climate change information in appropriate packages to encompass farmers with different cognitive and literacy skills could be an important policy intervention. Improving access to climate change information would also lead to increased motivation for action against the changing climate.

The empirical findings suggest that bean farming experience, farmers' membership to associations/groups, and literacy are crucial to understanding the trends and behaviour of climate change variables, i.e., precipitation characteristics and temperature fluctuations. Policies geared towards instituting or improving existing farmers' associations/groups should be supported, engaging experienced and literate farmers into providing co-operative platforms for information sharing, including climate change. Such kinds of policies could foster cross-fertilization of well-informed ideas among farmers; thereby improving their understanding and ultimately constructing the correct perception of the changing climate.

The importance of shocks and stresses, such as droughts or dry spells, floods or excess rain, pest and diseases, and hailstorms among others as a result of the changing climate in affecting smallholder bean farming calls for appropriate policies to improve access to and use of climate change adaptation strategies. The utilization of these adaptation strategies would reduce the effects of climatic shocks and stresses and thereby improve on yields in smallholder bean farming.

Policies and interventions which support development of adaptation strategies that are user friendly to both genders should be encouraged. Such policies would encourage full participation by both genders in the use of available adaptation strategies. The user friendliness of adaptation strategies to both genders provides a significant breaking of the barriers between genders, which restricts the use of a particular adaptation strategy and, therefore, allows for a wider choice of actions in dealing with the changing and varying climate.

Participation in decision-making and direct involvement in bean production activities in the face of climate change are key to improved production. The empirical findings suggest that age of household head, family size, bean farming experience, and gender are important factors

influencing participation in decision-making, and direct involvement in performing bean production activities in smallholder farming. This suggests that policies aimed at promoting integration of young farmers in decision-making on production activities appear to be an important intervention area that can help to maintain and strengthen the bean production chain. Promoting, improving, and enhancing gender consideration at every node of bean production activity could facilitate decision-making in smallholder farming.

Age appears to be crucial in accessing basic services, which is one of the components of the resilience measure. Policies befitting older farmers to access basic services would improve farm households' resilience, as they are part of the equation in household production activities and, hence, need to be supported. This can be done by establishing public institutions that offer the basic service at the most convenient distance to reduce mobility problems and improve access for older farmers. Again, literacy, gender, and household membership to associations/groups appear to be crucial to stability of the farm households. Policies should be supported that aim to improve farmers' literacy levels, gender balance, and membership to associations/groups to achieve households' stability. This can be done by rehabilitating and instituting adult learning, better gender consideration in developmental activities, and maintaining associations/groups. Improving production quantities, and climate change awareness in smallholder farming are crucial to achieving adaptive capacity. Policy interventions which are geared towards initiating activities to increase production quantity and providing climate related information to smallholder farmers should be supported. This can be through providing extension services on production activities and training on climate change issues, plus strategies for farmers to deal with the changing climate.

Resilience capacity differs across geographical locations, suggesting that one size fits all policy interventions would not work. Policies that support geographical locations based on their vulnerability should be encouraged. This can be done through implementing activities that best suits a particular geographical location, based on the extent to which the climatic shocks and stresses affect, or have affected, the smallholder farming community. The subsequent section highlights the limitations of the study and suggests areas of further research.

7.8 Limitations of the study and suggestions for future research

In its pursuit, this thesis used a mixture of qualitative and quantitative approaches to draw general conclusions, as captured in preceding sections. Nevertheless, the study acknowledges several limitations which became apparent during its course. Firstly, the study used principal component analysis (PCA) and standardized scores to generate indices for running regressions to estimate resilience, selected because of the latent nature of the variables used. Although this approach was used, the most suitable approach to determine resilience of households based on latent variables is structural equation modelling (SEM) where observed variables are employed to estimate the latent variables using a factor analysis model, and concurrently a regression analysis is employed to determine relations amongst the latent variables (Bollen, 1989). However, SEMs are more complex and require a larger sample size. Further studies using SEMs are highly recommended to provide further insights on resilience measures to climate variability and change in smallholder farming.

Secondly, this study's results are based on available cross-sectional data which assesses exposure and outcome simultaneously, thereby generally failing to provide evidence of a temporal relationship between exposure and outcome. For instance, some key findings might have been influenced by previous climatic and local economic conditions across geographical study locations. The cross-sectional data cannot be used to analyse behaviour of something over a period of time, such as farmers' perception over a given time period. In this respect, resilience to climate variability and change in smallholder farming can be more effectively analysed using panel data. Panel regression methods are known to capture long-term effects and reduce unobserved heterogeneity as a result of time invariant factors. This heterogeneity cannot be controlled adequately in studies with cross-sectional data and may lead to the risk of biased approximations (Klevmarken, 1989). Further research using panel data in estimating resilience to climate variability and change would be highly recommended to provide further insights into the relationships between climate resilience and smallholder farming systems.

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APPENDIX

Appendix 1. Ethical clearance

School of Agriculture, Policy and Development

**ETHICAL CLEARANCE
GRANTED**



Form 2. MSc PhD Staff Ethical Clearance Submission Form

PLEASE allow a minimum of 3 weeks for this process.

You must not begin your research until you have obtained consent as evidenced by this form returned from the APD student Office signed and dated. Ethical Clearance cannot be granted retrospectively.

This form can only be used if the application :

- Does not involve participants who are patients or clients of the health or social services
- Does not involve participants whose capacity to give free and informed consent may be impaired within the meaning of the Mental Capacity Act 2005
- Does not involve patients who are 'vulnerable'
- Does not involve any element of risk to the researchers or participants
- Does not involve any participants who have a special relationship to the researchers/investigators

If any of the above apply, please refer to the APD Ethics Chair to decide whether an application can be made through the APD review process or whether the application needs to be referred to the full University Committee.

It is the applicant's responsibility to check for any particular requirements of a funder regarding ethical review. Some funders may require that the application is reviewed by full University Committee and not the devolved School committee.

Full details of the University Research Ethics procedures are available at <http://www.reading.ac.uk/internal/res/ResearchEthics/reas-REethicshomepage.aspx> and you are encouraged to access these pages for a fuller understanding. Some helpful advice is available on this link <http://www.reading.ac.uk/internal/res/ResearchEthics/reas-REwhatdoinneedtodo.aspx> and the FAQs are particularly relevant.

ALL QUESTIONS MUST BE COMPLETED.

APD Ethical Clearance Application Reference Number : [Click here to enter text.](#)

1. APPLICANT DETAILS:

Main applicant name:	Kelvin Dambuleni
Name of academic supervisor/project investigator:	Dr Sarah Cardey and Prof Kelvin Balcombe
Email Address (decision will be emailed here):	gf875388@reading.ac.uk
MSc Student	☐
PhD Student	☒
Staff Member	☐
Other (please specify)	Click here to enter text.

2. PROJECT DETAILS:

Title of project: Understanding farm-gate resilience to climate variability and change among common bean smallholder farmers in Malawi: A gender-based perspective

Please provide a lay summary of the project, including what is being investigated and why: My study aims to understand ways in which the common bean smallholder farm households can be made resilient to climate variability and change through gender integration, and the extent to which this relationship can help contribute to improved food self-sufficiency, security, and income. Smallholder farm households are defined differently depending on different characteristics as revenues, socio-economic feature, land size, resource endowments, regions and countries among others. For purposes of this research, I define smallholder farm households as farmers who

6. APD ethics committee review. Section to be completed by APD Ethics Committee member.

Decision

Clearance refused

Clearance granted as presented

Clearance granted subject to revisions suggested

Referred to APD Research Ethics Chair

☐ Resubmission required

☐

☒ No need to resubmit once amended

☐ May require further information

Appendix 2. Study questionnaire

HOUSEHOLD QUESTIONNAIRE: SMALLHOLDER FARM HOUSEHOLD CLIMATE RESILIENCE, GENDER BASED DIMENSION

Introductory remark

Hello, my name is _____. We are conducting this survey in order to understand climate resilience among the common bean farm households in your village. The data will be used by a student studying at the University of Reading UK. Your response to these questions would remain anonymous. Taking part in this study is voluntary. If you choose not to take part, you have the right not to participate and there will be no consequences. Thank you for your kind cooperation”

INTERVIEW DETAILS

Questionnaire No.: ____ Date of Interview: ____/____/____ ID of Interviewer: _____

Start Time for the interview _____ (24HRS)

SECTION 1: HOUSEHOLD IDENTIFICATION

1.1 District: 1 = Dedza, 2 = Chikwawa, 3 = Nsanje 4 = Zomba: [_____] 1.2.EPA _____

1.3. Section _____ 1.4.Village _____

1.5 Name of the respondent _____ 1.6. Respondent's gender [Male = 1, Female = 0] ☐

1.7. Age of the respondent _____ 1.8. Household family size _____

1.9. Name of household head _____ 1.10. Age of HH _____

1.11. GPS reading of homestead; Way point number _____

1.12. Latitude (North) _____ 1.13. Longitude (East) _____

1.14. Altitude (meter above sea level) _____

SECTION 2: COMMON BEAN PRODUCTION ACTIVITIES

2.1. Do you grow common beans in your farm household?

Yes = 1, No = 0 (if not do not proceed with administering).

2.2. How long have you been growing common beans(years)

2.3. How much land in total does this farm household own?(acres)

2.4. How much land do you normally allocate to beans production?

2.5. How much labour operate on bean field in this HH in man days

2.6. How much seed do your farm household normally plant(kgs)

2.7. How much fertilizer (kgs) did you or normally apply on your bean field?

2.8. How much manure do you normally or did apply to bean field?

2.9. How much beans (kgs) do you normally harvest from your field every year?

2.10. Cropping activity on land in **Qn. 2.4**

Response **code 1**:

Self = 1, Spouse = 2, Self & spouse jointly = 3,

Spouse and other HH members = 4,

Self and other HH members = 5,

Other HH members = 6

Do you

participate in

making

decisions on

[....]

1=Yes

0=No

Who

makes the

decision

for the

activity?

[....]

Code1

Who

usually is

involved in

performing

the

work?[...]

Code 1

A0

A1

A2

a. Site selection

b. Land/bush clearing

c. Ridging/ploughing

d. Planting

e. Fertilizer application

f. Spray against pests & diseases

g. Harvesting

h. Transport beans from the garden

i. Threshing

j. Winnowing

k. Sorting

l. Post-harvest storage

Adapted from [Mugagga et al. \(2016\)](#); [Nakazi et al. \(2017\)](#)

SECTION 3: CLIMATE VARIABILITY AND CHANGE, AND ADAPTATION OPTIONS

3.1 Farmers' perceptions of climate variability and change

Questions: **Have you**

Options

3.1.1. Observed long-term change in the amount of main rainfall season in the past 10 years? (Yes=1, No=0)

3.1.2. If yes, (increased=1, decreased=0)

3.1.3. Observed long-term shift in the onset of main rainfall season in the past 10 years? (Yes=1, No=0)

3.1.4. If yes, (early onsets=1, Late onsets=0)

3.1.5. Observed long-term shift in the ending of main rainfall season in the past 10 years? (Yes=1, No=0)

3.1.6. If yes, (early ending=1, late ending=0)

3.1.7. Observed long-term change in temperature in the past 10 years? (Yes=1, No=0)

3.1.8. If yes, (increased=1, decreased=0)

3.1.9. What do you think has changed the rainfall and temperature?

3.1.10. What changes do you anticipate in the future regarding rainfall?

(increase in rainfall = 1, decrease in rainfall = 2, no change in rainfall = 3, I don't know = 4)

3.1.11. What changes do you anticipate in the future regarding temperature?

(increase in temperature=1, decrease in temperature =2 no change in temperature =3 I don't know=4)

3.1.12. What changes have you observed in productivity in the past 10 years for beans and other main crops this household grow?

(increasing 1, decreasing=2, varies=3, no change=4, I don't know=5)

3.2 Climatic shocks or stresses and its effects (code1. Extremely severe=1, Very

severe=2, Severe=3,

Significant=4, Somewhat significant=5,

Irrelevant=6,

I don't know=7)

Is your HH bean production affected by the following shocks [...]?
1=Yes, 0=No

How would you rank level of effect of a shock?
code 1

Between men and women who is heavily affected by shock/stress
1=men, 0=Women

Shock

3.2.1. Drought or dry spells

3.2.2. Floods or too much rain

3.2.3. Crop pests/diseases

3.2.4. Hailstorm

3.2.5. Heat wave

B1	B2	B3

Adapted from [Habtemariam et al. \(2016\)](#); [Limantol et al. \(2016\)](#).

3.3 Climate change adaptation strategies and farm household decision making

Adaptation strategy	Have you ever used the adaptation strategy in [....]? 1=Yes.0=No	Who decides on the adaptation strategy to use [....] code A	What benefits have you realized by using the adaptation strategy [....]? Code B

	C1	C2	C3
3.3.1. Change in planting time			
3.3.2. Use of drought tolerant varieties			
3.3.3. Irrigation			
3.3.4. Use soil and water conservation measures			
3.3.5. Intensive use of chemical fertilizers			
3.3.6. Crop rotation			
3.3.7. Fallow the fields			
3.3.8. Non-farm activities			
3.3.9. Early maturing varieties			

Code A: 1=self, 2=spouse, 3=jointly, 4=other household members.

Code B: 1=increased yield 2=increased income after sale 3=Food and nutrition security

SECTION 4.0 GENERAL OPINION/PERCEPTION OF CLIMATE VARIABILITY AND CHANGE

Q4.1. Please indicate how you perceive the changes in the following climate change or variability variables by ticking one box on each row:

a. Rainfall

b. Temperature

c. Wind

d. Sun's heat

e. Frequency of droughts

f. Frequency of drying rivers

g. Incidence of crop diseases

h. Incidence of animal diseases

i. Incidence of human diseases

j. Frequency of hunger

☐	Decrease greatly	☐	Decrease slightly	☐	Stay the same	☐	Increase slightly	☐	Increase greatly
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	
☐		☐		☐		☐		☐	

Q4.2. Please indicate how much you agree or disagree with the following statements about perceived effects of climate change on humans, livestock, and crops ticking one box on each row:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
a. Decreased rainfall, unpredictable rainfalls, breaks in rainy seasons, early and late rains has resulted in hunger, food insecurity, and loss of livelihoods	☐	☐	☐	☐	☐
b. Decreased rainfall, unpredictable rainfalls, breaks in rainy seasons, early and late rains has resulted in loss of crops and loss of seeds	☐	☐	☐	☐	☐
c. Decreased rainfall, unpredictable rainfalls, breaks in rainy seasons, early and late rains has resulted in lack of fodder and livestock deaths	☐	☐	☐	☐	☐
d. Increased temperatures have resulted in hunger, food insecurity and loss of livelihoods	☐	☐	☐	☐	☐
e. Increased temperatures have resulted in drying of pasture leading to lack of fodder and livestock deaths	☐	☐	☐	☐	☐
f. Increased temperatures have resulted in loss of crop and loss of seeds	☐	☐	☐	☐	☐
g. Increased wind has resulted in falling of cultivated crops	☐	☐	☐	☐	☐
h. Increased frequency of droughts has resulted in hunger, food insecurity, and loss of livelihoods	☐	☐	☐	☐	☐
i. Increased frequency of droughts has resulted in lack of fodder and deaths of livestock	☐	☐	☐	☐	☐
j. Increased frequency of droughts has resulted in loss of crops and loss of seeds	☐	☐	☐	☐	☐
k. Increased incidence of crop pests and diseases, animal pests and diseases has resulted into human sickness	☐	☐	☐	☐	☐
l. Increased incidence of animal pests and diseases has resulted in poor livestock health, low production, and death of livestock	☐	☐	☐	☐	☐
m. Increased incidence of crop pests & diseases, has resulted into poor yields and loss of crops	☐	☐	☐	☐	☐

Q4.3. Please indicate how much you agree or disagree with the following statements ticking one box on each row:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
a. In times of climate shocks farm households received assistance from govt & NGOs	☐	☐	☐	☐	☐
b. Farm households have their own capital or they successfully borrow formal credits to restart their production after climate related shock	☐	☐	☐	☐	☐
c. You are satisfied with the frequency of assistance in times of climate shocks	☐	☐	☐	☐	☐
d. In your opinion, targeting of the assistance during climate shocks is normally good	☐	☐	☐	☐	☐
e. Decreased common bean market price is associated with opportunities for new productions	☐	☐	☐	☐	☐
f. Risks in common bean farming are lower than those in other legume farming activities	☐	☐	☐	☐	☐
g. Diversified income generated activities help farm households to easily restart a new bean production after disaster	☐	☐	☐	☐	☐
h. Loss of common bean farming has no serious impact on our daily basic needs	☐	☐	☐	☐	☐
i. Farm households have gained many practical experiences about common bean farming after each failing season.	☐	☐	☐	☐	☐
j. Farm households have applied new production tools/practices (invented by other farmers) which really help to reduce bean farming risks.	☐	☐	☐	☐	☐
k. Farm households are confident that changes in common bean production techniques help their bean farming less affected by (natural & market) shocks than other households.	☐	☐	☐	☐	☐

Q4.5. Please indicate how much you agree or disagree with the following gendered statements about climate change by ticking one box on each row:

	☐ Strongly disagree	☐ Disagree	☐ Neither agree nor disagree	☐ Agree	☐ Strongly agree
a. Both women and men are affected the same way with climate variability and change at farm household	☐	☐	☐	☐	☐
b. At farm household level, there are no differences in the way men and women respond to climate change	☐	☐	☐	☐	☐
c. Access to climate change information is the same at farm household level between men and women	☐	☐	☐	☐	☐
d. Climate change adaptation strategies are user friendly to both men and women	☐	☐	☐	☐	☐
e. Choices to climate adaptation strategies are made jointly at farm household	☐	☐	☐	☐	☐
f. Women are given chances to exercise their knowledge in dealing with climate change at farm household level.	☐	☐	☐	☐	☐
g. When climate induced events occur, women and men are given equal assistance	☐	☐	☐	☐	☐
h. Both men and women are involved the same way in destroying the natural resources	☐	☐	☐	☐	☐
i. Low crop yield at farm household level is caused by non-involvement of women to help choose the right adaptation strategies to climate change?	☐	☐	☐	☐	☐
j. Even though women suggest ways of tackling climate change, their voice is not heard at farm household level	☐	☐	☐	☐	☐
k. Men don't usually value the innovativeness of women in dealing with climate change	☐	☐	☐	☐	☐
l. If women are included in decision making processes around production, farm households would be food secure	☐	☐	☐	☐	☐

SECTION 5.0 FARM HOUSEHOLD CLIMATE RESILIENCE (SUBJECTIVE)

Q4.5. Please indicate how much you agree or disagree with the following statements about farm household subjective resilience to climate variability and change by ticking one box on each row:

5.1. If heavy threats posed by extreme weather events are to occur in your area tomorrow, what would be your comment if I say your household would be able to successfully cope with the threats, fully recover from the damage caused within 6 months (Coping capacity)?

Strongly disagree ☐ Disagree ☐ Neither agree nor disagree ☐ Agree ☐ Strongly agree ☐

5.2. If the rate and intensity of extreme weather events are to increase significantly in the next 5 years, what would you comment if I say your household would have the ability to successfully adapt threats posed (Adaptive capacity-probing transformative capacity)?

☐ ☐ ☐ ☐ ☐

5.3. If heavy extreme weather events are to occur in your area tomorrow, your household would have access to sufficient financial resources to ensure that you fully recover from the threats posed, what could be your comment (Financial capital)?

☐ ☐ ☐ ☐ ☐

5.4. If heavy extreme weather events are to occur in your area tomorrow, your household would be able to draw on the support of family and friends to ensure that you fully recover from the threats posed, what do you say (Social capital)?

☐ ☐ ☐ ☐ ☐

5.5. What can you say if say, your household has learned considerably from you in a way they have dealt with past extreme weather events? This knowledge is crucial in successfully dealing with future events (Iterative learning).

☐ ☐ ☐ ☐ ☐

5.6. What would you comment if I say ‘If heavy extreme weather events are to occur in your area tomorrow, your household would have access to early-warning information to ensure that you are fully prepared for the threats posed’ (Knowledge and information)?

☐ ☐ ☐ ☐ ☐

Adopted from [Jones & Tanner \(2015\)](#).

SECTION 6.0. PARTICIPATION IN RURAL INSTITUTIONS, ACCESS TO KEY SERVICES, SOCIAL SAFETY NETS, STABILITY AND ADAPTIVE CAPACITY

Rural institutional participation

6.1. How many groups do you have membership?

6.2. Institution Type

Code 4: No input=1, Input into very few decisions=2, Input into some decisions=3, Input into most decisions =4, Input into all decisions=5.

Are you currently a member of any of the following group?

Yes=1, No=0

How much input do you have in making decisions in this [GROUP]?

Code 4

a. Savings and credit association

merry-go-round (chipereganyo)

c. Input supply group, farmer

d. Crop or seed production group

e. Water User's Association

f. Crop marketing group

g. Women's Association/group

h. Youth Association

i. Church/mosque

6.3. Access to Basic Services(ABS)

Service

Response

6.3.1. Distance to the nearest water source (km)

6.3.2. Distance to the nearest market (km)

6.3.3. Distance to the nearest health care centre(km)

6.3.4. Distance to the nearest all weather road (km)

6.3.5. Does the household have access to electricity? (Yes=1;No=2)

6.3.6. Does the household have access to telephone? (Yes=1;No=2)

6.3.7. Have any household member received credit (in cash or in kind) from any source? (Yes=1;No=2)

6.4. Social Safety Nets (SSN)

6.4.1. In times of livelihood shocks do you receive any assistance?(Yes=1;No=2)

6.4.2. Amount of cash and in kind assistance (MK/person/day)?

6.4.3. How satisfied are you with the quality of assistance? (Highly satisfied=1, Satisfied=2, Not satisfied=3, Highly unsatisfied=5)

6.4.4. Frequency of assistance(times received in a year)

6.4.5. Overall opinion of targeting(targeting the needy)(Assistance targeting the needy=1, Some not needy=2, Without distinction=3)

6.5. Stability(S)

6.5.1. How many family members in this household possess professional skills

6.5.2. Educational level of the household head

(1=read and write, 0=do not read and write)

6.5.3. Educational level of the household head

(1=primary school or higher,0=Lower than primary or higher)

6.5.4. Employment ratio (ratio of employed HH members to the household size)

6.5.5. Number of HH members who have lost a job

6.5.6. Income variation/stability(Increased=1; Same=2; Decreased=3)

6.5.7. Assistance dependency (ratio of monetary value of assistance to total income)

6.5.8. Quality of assistance(Increased=1; Same=2; Decreased=3)

6.5.9. Number of institutions providing medical care

6.5.10. Quality of education(Increased=1; Same=2; Decreased=3)

6.6.Adaptive Capacity (AC)

6.6.1. Number of HH income sources

6.6.2. Dependency ratio-number of family members below aged 15-64
and those aged 15 and above 64(simple calculations needed)

6.6.3. Does your farm household access climate early warning messages through the
following modes? (1=Yes 0=No)

a. Print media (newspapers, magazines, newsletters, leaflets, brochures,
pamphlets road banners, bill boards etc.)?

b. Electronic media (Radio, TV, documentary, interactive website, social
media texting using mobile phone etc.)?

c. Direct stakeholder engagement

d. Extension workers

e. Beating drums, blowing whistle, shouting & using megaphones

f. Farmer to farmer

g Does your household have a local business ownership (1=Yes 0=No)

6.6.4. As a farm household what action do you take upon receiving
climate early warning message through any one of the dissemination
modes? 1=Prepare; 2=Mitigate; 3=Prevention

SECTION 7: HOUSEHOLD FOOD INSECURITY ACCESS SCALE (HFIAS).

#	Question	Response Options	Code
1	In the past, did you worry that your household would not have enough food?	0=NO (skip to Q2) 1=Yes	
1.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
2	Were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0=NO (skip to Q3) 1=Yes	
2.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
3	Did you or any household member have to eat a limited variety of due to a lack of resources?	0=NO (skip to Q4) 1=Yes	
3.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
4	Did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	0=NO (skip to Q4) 1=Yes	
4.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
5	Did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0=NO (skip to Q6) 1=Yes	
5.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	

6	Did you or any household member have to eat fewer meals in a day because there was not enough food?	0=NO (skip to Q7) 1=Yes	
6.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
7	Was there ever no food to eat of any kind in your household because of lack of resources to get food?	0=NO (skip to Q8) 1=Yes	
7.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
8	Did you or any household member go to sleep at night hungry because there was not enough food??	0=NO (skip to Q9) 1=Yes	
8.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	
9	Did you or any household member go a whole day and night without eating anything because there was not enough food?	0=NO (can't skip further) 1=Yes	
9.a	How often did this happen?	1=Rarely (once or twice in the past year) 2=Sometimes (three to ten times in the past year) 3=Often (more than ten times in the past four weeks)	

Adapted from [Coates et al. \(2007\)](#).

SECTION 8: HOUSEHOLD DIETARY DIVERSITY SCORE (HDDS)

Q#	Food group	Example	Yes=1 No=0
1	CEREALS	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g., bread, noodles, porridge/other grain products) + insert local foods, e.g., nsima, porridge or paste	☐
2	WHITE ROOTS AND TUBERS	white potatoes, white yam, white cassava, or other foods made from roots	☐
3	VITAMIN A RICH VEGETABLES AND TUBERS	Pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A rich vegetables (e.g., red sweet pepper)	☐
4	DARK GREEN LEAFY VEGETABLES	dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach	☐
5	OTHER VEGETABLES	other vegetables (e.g., tomato, onion, eggplant) + other locally available vegetables	☐
6	VITAMIN A RICH FRUITS	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A rich fruits	☐
7	OTHER FRUITS	other fruits, including wild fruits and 100% fruit juice made from these	☐
8	ORGAN MEAT	liver, kidney, heart or other organ meats or blood-based foods	☐
9	FLESH MEATS	beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects	☐
10	EGGS	eggs from chicken, duck, guinea fowl or any other egg	☐
11	FISH AND SEAFOOD	fresh or dried fish or shellfish	☐
12	LEGUMES, NUTS AND SEEDS	dried beans, dried peas, lentils, nuts, seeds or foods made from these (i.e., hummus, peanut butter)	☐
13	MILK AND MILK PRODUCTS	milk, cheese, yogurt or other milk product	☐
14	OILS AND FATS	oil, fats or butter added to food or used for cooking	☐
15	SWEETS	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes	☐
16	SPICES, CONDIMENTS, BEVERAGES	spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic beverages	☐

Adapted from [Bader & Claude \(2014\)](#).

Interview end time..... (24Hrs).

THANK THE RESPONDENT FOR PARTICIPATING IN THE STUDY

Appendix 3. Focus group discussions protocol

- a. Welcome remark
- b. Overview of the topic
- c. Ground rules

Section 1: Opening questions

Section 2: Farmers' perceptions of climate variability and change

Section 3: Farmers' indigenous knowledge of climate variability and change

Section 4: Smallholder farm household's climate change resilience.

Section 5: Decision making at farm household level for production in the face of climate change.

Section 6: Ending questions

a. Welcome remark

Good morning and welcome to our session. Thanks for taking the time for joining us to talk about climate variability and change in your area. My name is Kelvin Dambuleni and I am in my second year of PhD in Agriculture and Food Economics. Assisting me are I will soon be handing out the consent forms for you to fill. Should there be any queries or questions regarding this, please feel free to ask.

b. Overview of the topic

Our topic of discussion today seeks to explore farmers' understanding and perceptions of climate variability and change. The purpose of this discussion is to find out how common bean smallholder farmers recover, adapt and cope to the changing climate.

We would like to encourage you to give out explanations about how farmers are affected with the changing climate and how can they thrive in the face of climate change.

c. Ground rules

There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we're just as interested in negative comments as positive comments, and at times the negative comments are the most helpful.

Your comments are very valuable, as such to avoid missing any comment and that we can't write fast enough to capture them all down, we have decided to record the session as you may have probably noticed the presence of the audio recorder amidst us. You may be assured of complete confidentiality. Our report will not use any names in any way. Please feel free to be frank and to share your point of view, regardless of whether you agree or disagree with what you hear. My duty is to make sure that I ask questions, listen, and that everyone is given chance in order that we hear all your opinions. I will take note of all individual dominance during discussions and may ask you to give chance to others. Again, if you are dormant I may call on you just to make sure everyone has a chance to contribute their ideas.

Please put your phones on silent mode if you may have one and feel free to quietly step out to answer your calls. You may also feel free to walk out for the washroom. This session is expected to take no more than 60 minutes with no breaks.

SECTION 1: OPENING QUESTIONS ON CLIMATE VARIABILITY AND CHANGE

Well, let's begin. Let's find out some more about each other by going around the table one by one. Tell us your name and where you live.

As indicated in the communication for this group, we will be discussing on local climate change issues and resilience strategies. Ultimately, climate is a term that has had no unanimity among climatologists, and let alone climate change, trend or fluctuations ([Houghton, 2002](#)). Consequently, it is imperative to start this discussion with your broad spectrum opinions on climate change.

What is climate change to you?

[Memo to moderators:](#)

How would you define the term climate change?

What specific attributes/factors explain climate change?

What causes climate change?

If at all, how do you think climate change is something that is affecting or is going to affect you, personally?

How would you explain the relationship between climate change and common bean production, and other crops in general?

In what way(s) is it affecting you, or is it going to affect you?

SECTION 2: FARMERS' PERCEPTIONS OF CLIMATE VARIABILITY AND CHANGE

How do you perceive climate variability and change?

Memo to moderators:

The discussants mentioned specific attributes that explain climate variability and change. These have to be arranged in a matrix or each has to be followed up in the order provided with the following questions to capture perceptions of specific attributes of climate change.

What has changed (change)?

How has it changed? Increase, decrease, positive or negative (effect)?

What effect does it have on farming (Impact)?

What effect does it have on livelihood (Impact)?

Who is more affected between men and women and why (Gender)?

What are the consequences of these effects (Vulnerability)?

What actions the community members are taking to overcome challenges and mitigate and avoid risks (Adaptation strategies)?

What kind of support is needed (external help) or should the community be taking (Support)?

SECTION 3: FARMERS INDIGENOUS KNOWLEDGE AND AWARENESS OF CLIMATE VARIABILITY AND CHANGE

What are the sources of climate change information?

Memo to moderators:

Sources of information as cited by the discussants should be compared against the trust scale (1.A lot, 2.A little, 3.Not very much, 4.Not at all, and 5.can't choose)

Where have you heard about climate change?

If any, what differences exist between men and women in accessing the information from the sources [....]?

How much you would TRUST information about climate change if you heard it from [....], and why would you trust it that way?

Where do we source local knowledge to tackle climate change impacts?

What local knowledge do you use to tackle the impacts of climate change?

How do those local approaches compare with new technologies in tackling climate change?

SECTION 4: SMALLHOLDER FARM HOUSEHOLD'S CLIMATE CHANGE RESILIENCE.

What factors can help smallholder farm households' resilience to climate variability and change?

Memo to moderators

Resilience is a complex term which attracts a variety of definitions based on the context it is used. For purposes of this study, resilience is defined as the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions (Walker *et al.*, 2004).

Income and food access.

How would you assess yourself on average in terms of total income per year?

How would you assess yourself on average in terms of monthly per capita income?

What has been your food security status over the past five years?

What kind of food stuffs do we usually eat daily?

Access to basic services

Memo to moderators:

There is a need for follow up questions in terms of distance, time, and quality where applicable.

How comfortable do you feel to move from your village to a nearest health centre?

How easy is it to move from your village to the nearest market place?

How do you access the early warning information to climate change?

Assets

How do you rate your farm households in terms of livestock owned?

How do you assess your access to irrigation water?

How do you assess your access to irrigation equipment and improved varieties?

Where do we usually access credit for agricultural production and other livelihood activities?

Social safety nets

In an event of a shock, who assists you with cash in kind?

What do you think about the quality of assistance?

Would you please comment of the frequency of assistance?

What do you think of the overall targeting of the assistance?

Adaptive capacity

What are the sources of income in your farm households?

What coping strategies do you put in place to adapt to climate change?

What activities do you engage into to keep up to the future?

SECTION 5: DECISION MAKING AT FARM HOUSEHOLD LEVEL FOR PRODUCTION IN THE FACE OF CLIMATE CHANGE.

Power dynamics at farm-gate level

Memo to moderators:

Prompt the farmers identify farm-gate production activities and follow up on decision-making process to each activity and direct involvement in performing a given activity.

Common bean production activities

What agronomic activities do you practice in your common bean production?

Note to moderators:

Please ask why on whosoever makes a decision on an activity, and for usual involvement in performing the work.

Who makes the decision between men and women for the activity [...]?

Who is directly involved in performing the work [...]?

Section 6: Ending questions

We have really spent a lot of time together discussing, I now invite anyone who has any other addition points and suggestions regarding the topics we have discussed to come forth. This is can be of great importance to help shape my study.

Well, this marks the end of our discussion today. Thank you very much, I have really appreciated your feedbacks and time here.

Appendix 4. Trend analysis protocol

- a. Welcome remark
- b. Overview of the topic
- c. Guidelines

Section 1: Opening questions_ listing of local climate indicator by farmers

Section 2: Matrix preparation of the identified aspects of trend analysis

Section 3: Explaining the matrix

Section 4: Copying the matrix

- a. Welcome remark

Good morning/evening and welcome to our session. Thanks for taking the next **60 minutes** to join us to talk about how the climate is changing. My name is Kelvin Dambuleni, a second year PhD student in Agricultural and Food Economics at the University of Reading and assisting me are.....I will soon be distributing copies of informed consent and confidentiality form to you all and read aloud for benefit of those who cannot read. Verbal agreement will be tapped. Please feel free to ask should there be queries or questions regarding this.

- b. Overview of the topic

Our discussion today will focus on understanding of the present situation of the changing climate, and changes that have taken place over the years. The main aim of our discussion is to establish the changes that have occurred as a result of climate variability and change in different aspects of life.

We would like to encourage you to take account of the past and of how things have changed and, hence, also provide a historical perspective.

- c. Guidelines

Before we start, I would like to remind you that there are no right or wrong answers in this discussion. We are interested in knowing what each of you think, so please feel free to be frank and to share your point of view, regardless of whether you agree or disagree with what you hear. It is very important that we hear all your opinions.

Please speak in a clear voice, loud enough for everyone to hear. Also, please speak one at a time and try not to interrupt another speaker. We won't be taking names. Only the actual comments expressed or submitted will be noted, not who said what during the session. You've probably noticed the voice recorder. We're tape recording the session because we don't want to miss any of your comments. People often say very helpful things in these discussions and we can't write fast enough to get them all down.

We recognize the importance of cell phones but please we ask that you put your phones on silent mode if you may have one, and feel free to quietly step out to answer your calls. You may also feel free to walk out for the washroom.

SECTION 1: OPENING QUESTIONS ON LOCAL INDICATORS CLIMATE VARIABILITY AND CHANGE

Listing of local climate indicators by participants

Let's start by going around the circle and having each person introduce themselves by mentioning your name and where you live.

The perception and understanding of climate change by non-experts has been a topic of interest for researchers and policy makers as perceptions of climate change vary among people (Habtemariam *et al.*, 2016). Again, there are various local climate change indicators which differ across location and space. These include four main types of local climate indicators (WIREs, 2016):

- 1) Local observations of climate change,
- 2) Observed impacts on physical systems,
- 3) Observed impacts on biological systems and
- 4) Observed impacts on socio-economic systems and health.

It is, therefore, important to ask the farmers to list the local climatic indicators they know and face.

Memo to the facilitators:

Ask the participants to list the local indicators of climate variability and change through brainstorming to come up with the list for trend analysis.

If the list becomes endless, ask them to select what they think are the most important ones.

What are the local indicators of climate variability and change that are known to likely affect farm household livelihood?

SECTION 2: MATRIX PREPARATION THE IDENTIFIED ASPECTS OF TREND ANALYSIS

Memo to facilitators:

Ask the participants to make a matrix on the ground/on the flip chart using chalk/marker. Ask them to represent the top to down the listed aspects of climate variability and change and left to right the fixed landmark years.

Appendix 3 Table 3.1 Trend analysis matrix

#	Aspects of climate variability and change	Fixed landmark years		
		Present	5-10 years	10-15years
1				
2				
3				
4				
.				
n				

Ask the participants to represent the listed aspects by using symbols or visuals.

Ask the participants to take up one of the listed local indicators of climate change and depict the present situation in the relevant cells using symbols, visuals, seeds stones etc. and move to the next landmark until all the listed aspects are satisfied.

Ask the participants if they are satisfied with the diagram or they may wish to make any changes.

Find out if new aspects came up during the process and that they would like to add (this helps to figure out some important aspects which may not feature on the list but are important and of interest to the study).

SECTION 3: EXPLAINING THE MATRIX

Memo to the facilitators

Encourage the participants to discuss their findings and reflect on them.

What major trends and findings is the diagram depicting?

What can be done to it?

Who can play a role in it?

What can you and local participants do to it?

What can you do with a little assistance from outside?

Memo to facilitators

Interviewing the diagram (gain an in-depth understanding of the trend and clarify your doubts).

Explore the impacts of the trends established to the farm household.

SECTION 4: COPYING THE MATRIX

Memo to facilitators

Transfer the information from the diagram onto a sheet of paper with details of the legend, the scoring system, the participants, facilitators, location, and date.

Thank the participants for their active involvement and their time.

Appendix 5. Pair-wise ranking protocol

- a. Welcome remark
- b. Overview of the topic
- c. Ground rules

Section 1: Opening questions

Section 2: Drawing a grid/matrix for pair-wise ranking

Section 3: Filling the pair-wise ranking grid/matrix

Section 4: Participants explanation of the grid output

Section 5: Copying the grid/matrix

- a. Welcome remark

Good morning/evening and welcome to our session. Thanks for taking the next **60 minutes** to join us to talk about how the climate resilience. My name is Kelvin Dambuleni, a PhD student in Agricultural and Food Economics at the University of Reading and assisting me are.....I will soon be distributing copies of informed consent and confidentiality form to you all and read aloud for benefit of those who cannot read. Verbal agreement will be tapped. Please feel free to ask should there be queries or questions regarding this.

- b. Overview of the topic

Our discussion today will focus on how smallholder farm households prioritize different climate resilience mechanisms. We aim to understand decision-making processes and factors that influence people's choices of climate resilience mechanisms at farm household level.

- c. Ground rules

Before we start, I would like to remind you that there are no right or wrong answers in this discussion. We are interested in knowing what each of you think, so please feel free to be frank and to share your point of view, regardless of whether you agree or disagree with what you hear. It is very important that we hear all your opinions.

Please speak in a clear voice, loud enough for everyone to hear. Also, please speak one at a time and try not to interrupt another speaker. We won't be taking names. Only the actual comments expressed or submitted will be noted, not who said what during the session. You've probably noticed the voice recorder. We're tape recording the session because we don't want to miss any of your comments. People often say very helpful things in these discussions and we can't write fast enough to get them all down.

While we appreciate the importance of cell phones but please we ask that you put your phones on silent mode if you may have one, and feel free to quietly step out to answer your calls. You may also feel free to walk out for the washroom.

SECTION 1: OPENING QUESTIONS ON FARM HOUSEHOLD CLIMATE RESILIENCE

Detailed list of climate resilience mechanisms

Let's start by going around the circle and having each person introduce themselves by mentioning their names and where they live.

Concept of resilience

The concept of resilience gets its application in different fields with varied definitions (Hoddinott, 2020) (IFPRI, 2013). For the purposes of this work, climate resilience is regarded as the ability of farm households to absorb and recover from climate induced shocks and stress (Tambo, 2016). These shocks include droughts, dry spells, rise in temperatures and floods which reduce household's resilience and increase vulnerability to future shocks.

Memo to the facilitators:

Ask the participants to discuss among themselves and come up with a list of resilience strategies that they use in the face of climate variability and change. As the strategies are being mentioned during the process, summarise and note them down.

What are the resilience strategies that you use in the face of climate-induced shocks in your farm households?

Note: once the strategies seem exhausted, ask the participants what other strategies are missing on the list or if they would want to edit the list.

SECTION 2: DRAWING A GRID/MATRIX FOR PAIR-WISE RANKING

Memo to facilitators:

Ask the participants to write or depict the strategies on small cards. Symbolic or visual depiction can also be used where necessary especially where a significant number of participants are not literate. For each strategy there is need for two cards with a strategy written and depicted for the exercise.

Draw a grid on the ground using chalk or on flip chart using markers with the number of roles and columns equivalent to number of strategies identified for pair-wise ranking.

Appendix Table 4.1 Pair-wise grid/matrix

<i>Resilience Strategies</i>	<i>Resilience strategies</i>					
	1	2	3	4	5	6
1	X					
2		X				
3			X			
4				X		
5					X	
6						X

SECTION 3: FILLING THE PAIR-WISE RANKING GRID/MATRIX

Memo to facilitators:

Take one and start comparing it all the other cards bearing the resilience strategies and continue with all other remaining cards until finishing.

Between X and Y strategies, which one do you like or prefer?

(This process continues until the list is satisfied).

Record the preferences in the grid by putting a name of the strategy, number, symbol etc. of the preferred strategy in an appropriate cell.

Count how many times each strategy has been preferred and note it at the end of the row.

SECTION 4: PARTICIPANTS EXPLANATION OF THE GRID OUTPUT

Memo to the facilitators

Encourage the participants to discuss their findings and reflect on them.

Record the main points of discussion throughout the process.

What major trends and findings is the grid/matrix depicting?

What factors affect the choices of the climate resilience mechanisms?

Who can play a role in the choice of climate resilience mechanism?

What can you and local participants do in order to be resilient to the changing climate?

What can you do with a little assistance from outside to build on your resilience to climate change?

Memo to facilitators

Interviewing the diagram (gain an in-depth understanding of the trend and clarify your doubts).

Explore the impacts of the trends established to the farm household.

SECTION 5: COPYING THE GRID/MATRIX

Memo to facilitators

Transfer the information from the grid onto a sheet of paper with details of the legend, date, the participants, facilitators, location, and date.

Thank the participants for their active involvement and time.

Appendix 6. Variance inflation factors (VIF)

Independent variable	VIF
Age of household head	1.34
Land holding size	1.26
Group membership	1.19
Bean farming experience	1.24
Family size	1.18
Gender	1.24
Literacy	1.14
Climate change awareness	1.02
district	1.15

The results in appendix 5 show the VIF of approximately 1 suggesting no correlation. The variance inflation factor (VIF) is the ratio (quotient) of the variance of estimating some parameter in a model that includes multiple other terms (parameters) by the variance of a model constructed using only one term. It quantifies the severity of multicollinearity in an ordinary least squares regression analysis. It provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity. Multicollinearity is when there is correlation between predictors (i.e., independent variables) in a model; its presence can adversely affect regression results. The VIF estimates how much the variance of a regression coefficient is inflated due to multicollinearity in the model. Variance inflation factors range from 1 upwards. The numerical value for VIF tells you (in decimal form) what percentage the variance (i.e., the standard error squared) is inflated for each coefficient. A **rule of thumb** for interpreting the variance inflation factor:

- 1 = not correlated.
- Between 1 and 5 = moderately correlated.
- Greater than 5 = highly correlated.

Exactly how large a VIF has to be before it causes issues is a subject of debate. What is known is that the more your VIF increases, the less reliable your regression results are going to be. In general, a VIF above 10 indicates high correlation and is cause for concern.