DETERMINANTS OF HOUSEHOLD RESILIENCE TO DRY SPELLS AND DROUGHT IN MALAWI: A CASE OF CHIPOKA

MSc. (AGRICULTURAL & APPLIED ECONOMICS) THESIS

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DECLARATION

I, Taonga Francisco Banda, declare that this thesis is a result of my own original effort and work, and to the best of my knowledge, the findings were never submitted to the University of Malawi or elsewhere for the award of any academic qualification. Where assistance was sought, it has been accordingly acknowledged.

Taonga Francisco Banda

Signature: ______________________________

Date: ___________/__________/_________

CERTIFICATE OF APPROVAL

We, the undersigned, certify that this thesis is a result of the author's own work, and to the best of our knowledge, it has never been submitted for any other academic qualification within the University of Malawi or elsewhere. The thesis is acceptable in form and content, and that satisfactory knowledge of the field was demonstrated by the candidate through an oral examination held on 20/05/ 2015

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Signature: ____________________________

Date: ________/________/__________

DEDICATION

To my late mother

Rhoda “Abiti Herbert” Kang’oma

Your courage and hard work in teaching us the values of life has brought dividends that you cannot enjoy

This work is duly dedicated.

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ABSTRACT

The study was aimed at identifying key factors that enhance resilience to prolonged dry spells and droughts among smallholder farmers in Chipoka Extension Planning Area (EPA) in the lakeshore district of Salima. The study area was selected because it experiences dry spells on a regular basis. The major contribution of this study is the construction of the Drought Resilience Index (DRI), which was used as a measure of drought resilience, and its use to determine the effect of resilience on the welfare of the farming families. Realising that smallholder farmers are not passive but active in responding to events that threaten their livelihoods, the study was aimed at identifying how factors such as household assets, social capital, size of land held by the farming household, among other factors help the farmers to absorb effects resulting from the effects of prolonged dry spells and droughts. The analytical framework used in the study assumed that resilience of a given household at a given time depends primarily on the options available to that household for making a living, which in turn affect the response of the household to adverse occurrences. Households whose options are stable and have a high adaptive capacity are said to be more resilient than those whose options are unstable and have less adaptive capacity. The study used principal component analysis (PCA) to reduce changes in actual household consumption and the number of months a household remains with food in normal and drought years to come up with the drought resilience index (DRI). To capture the effect of drought on farmers' welfare, a stochastic frontier production function was estimated with output as the dependent variable and the drought resilience index among the explanatory variables. Results of the study reveal that most households in Chipoka were not resilient to effects of dry spells and that factors such as age of the household head, size of the farm family, land holding size, number of immediate family members living outside the household are some of the factors that affect the resilience of farming households. The study also found that households that were resilient to dry spells were likely to have improved farm household welfare. The study recommends promotion of productivity enhancing technologies. Another recommendation calls for promotion of drought resistant crops and diversification into off-farm economic activities. For state and non-state actors working in the study area, a recommendation is made that they must target their aid efficiently to achieve the intended purpose in enhancing resilience.

Key words

Dry spells, droughts, vulnerability, resilience, livelihood, welfare.

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immuno Deficiency Syndrome
COOPI	Cooperazione Internazionale
DRI	Drought Resilience Index
FAO	Food and Agriculture Organisation
IPCC	Intercontinental panel on Climate Change
GDP	Gross Domestic Product
ENSO	El Niño - Southern Oscillation
HIV	Human Immunodeficiency Virus
PCA	Principal Components Analysis
KMO	Kaiser-Meyer-Olkin
TA	Traditional Authority
WFP	World Food Program
WVI	World Vision International

CHAPTER ONE

BACKGROUND TO THE STUDY

1.1 Introduction

Dry spells and droughts have been known to contribute adversely to the livelihoods of many people in developing countries. For example, in Malawi, over 85 per cent of the people live in rural areas and depend on natural resources mainly soils, water, fisheries from inland lakes and fuel wood from forests for energy (Lunduka *et al.*, 2010). Despite this, the country has experienced adverse extreme climatic conditions over the past decades, which have affected the use of natural resources and the subsequent livelihoods of many people that depend on them.

As a country, Malawi is prone to natural and human induced shocks. For example fifteen out of 28 districts in the country are prone to different natural and human induced hazards, basing on historical data and climate of the areas (Phiri, 2013). The flood plains, wetlands and forests of the Lower Shire Valley (which covers the districts of Nsanje, Chikhwawa and Mwanza) and the Rift Valley areas lying along the shores of Lake Malawi (namely Mangochi, Salima and Karonga districts) are among those areas particularly affected by climate variability with dry spells, droughts and floods among the most common (World Bank, 2011). The incidences, intensity and magnitudes of prolonged dry spells, droughts and floods have increased over the past three decades with negative consequences for food and water security, water quality and the sustainability of livelihoods of rural communities (Nangoma, 2007; World Bank, 2011). For example, over the past decades, the country has experienced some of the worst droughts (1991/2) and floods (2001/2) and almost every year a significant number of people are affected by prolonged dry spells, drought and floods in these areas. These disasters have resulted in low agricultural output, with consequences on hunger, malnutrition especially among under five children, loss of life (deaths), disruption of electricity and other socio-economic and industrial activities that have also affected the economy (United Nations Development Programme [UNDP], 2012).

1.2 Statement of the problem

Smallholder farmers in Malawi are faced with constraints that have undermined their potential to produce adequate output. Some of the notable constraints include declining soil fertility, increasing population, resulting in higher demand for agricultural land), rising prices of farm inputs, low prices of farm output, which together with other challenges has resulted in a cost-price squeeze for farmers. In addition to these constraints, producers have also been victims of unpredictable rainfall and other weather related problems resulting from climatic variability. An analysis of impacts of climate change reveals that the country has been affected in all areas of development (Nangoma, 2007). Of all the areas affected, agriculture has been singled out as the most severely affected sector. Adverse conditions such as prolonged dry spells, droughts and floods have presented new challenges because they are exogenous shocks beyond the influence of the smallholder producer. Nangoma (2007) argues that Malawi relies on rain-fed agriculture and droughts have resulted in poor crop yields or total crop failure, leading to serious food shortages, hunger and malnutrition. To substantiate Nangoma's argument, the Malawi Vulnerability Assessment Committee (MVAC) reported that about 9.5 percent of the Malawi population (approximately 1.1 million people) were food insecure between the months of October, 2013 and March, 2014 (FEWS NET, 2013). This was partly attributed to poor harvests that some parts of the country registered due to unfavourable weather conditions, such as floods, droughts and dry spells. Farmers that are resilient are better able to deal with effects of shocks that affect them, hence the need to study resilience of smallholder producers in Chipoka.

Many studies have been conducted to determine how smallholder farmers have responded to some of the problems they face relating to production and marketing (for example Matchaya, 2007 and Kankwamba et al., 2012). To our knowledge, no study has been specifically commissioned to study resilience to dry spells and droughts among maize producers in Salima. Dry spells that are very frequent in Salima have been known to undermine farmers' ability to produce enough for household use (GoM, 2006). This study was motivated by the revelation that Chipoka is a dry area despite being close to Lake Malawi, where fresh water could be easily tapped and used for irrigation. Despite the areas being dry, it is documented that impacts of climatic change and variability are not evenly distributed with people that are most vulnerable and exposed to the worst of the impacts are those that are least likely to cope with the associated risks (Adger, et al. (2003), IPCC (2001) and Smit *et al.* (2001)). The present study was conducted to identify factors that affect resilience among smallholder maize producers in Chipoka. In Salima district alone, it has been reported that almost every year a significant proportion of the farming community is affected by dry spells (GoM, 2006). For example, the Ministry of Agriculture, Irrigation and Water Development of the Government of Malawi has indicated that Salima district has been among the districts that have been affected dry spells and droughts in the country. With about 80 percent of the people in Salima district deriving their livelihood from agriculture (GoM, 2006), it would be vital to understand the key factors that enhance resilience and how droughts and dry spells have affected the welfare of smallholder farmers in the district.

1.3 Justification for the study

Knowledge of what factors enhance resilience among smallholder farmers affected by dry spells and drought would be of significant help to policy makers, Non-Governmental Organisations (NGOs) and other stakeholders to formulate strategies and interventions that will enhance resilience in affected areas. Most studies that have been carried out have looked at regional and national losses that have been incurred as a result of natural disasters. Some of the studies that have been conducted to find specific losses at district level have mainly concentrated on districts from the Southern parts of Malawi such as Balaka, Nsanje and Chikhwawa, (for example Phiri *et al.* ,2012) and Magombo et al., 2011) . There have been very few studies (if any) that have focused on the lakeshore districts especially to study factors that enhance resilience among smallholder farmers in Salima district. The present study aimed to provide information on what factors enhance resilience among smallholder farmers who have been affected by prolonged dry spells and drought in the lake shore district of Salima, which has been identified as one of the districts that are vulnerable to adverse environmental phenomena along the Central Lakeshore areas. This is because farmers that are resilient are better able to deal with shocks that threaten their livelihood.

The findings of this study provide a basis for strategy formulation and interventions that will help policy makers and development practitioners in their efforts to reduce adverse effects of these occurrences on human welfare, particularly on smallholder farmers who form the majority of the population in Malawi. Understanding how farming households become resilient to dry spells and drought will help concerned development institutions to design their interventions in ways that will enhance people's ability to manage risks over time and this will reduce the need for emergency interventions that are undertaken when these disasters strike. Keil *et al.* (2006) argue that it is proper to study systems at both community and individual levels if we are to measure the impact of dry spells and drought. For this reason, community and individual characteristics were included in the study. The present study sets a basis for further research in other parts of the country in which farmers have also been negatively affected by natural shocks.

1.4 Definition of key terms and scope of the study

1.4.1 Meaning of the terms vulnerability and resilience

Defining terms used in the study was considered appropriate to understand the scope of the present study. This was considered appropriate because of the confusion that arises when the concepts are applied in different branches of science and because the terms may be new to economics while they may not be new in ecological science. This section was aimed at defining the terms vulnerability and resilience and how the two terms relate to each other.

Some authors have argued that the term resilience has its origins from ecology where Holling (1973) coined the term for ecosystems and defined it as "a measure of the ability of these systems to absorb changes and still persist", (Holling, 1973:14). Several authors have refined Holling's definition for the term resilience and provided improvement on it. For example, Blaikie *et al.* (1994), defined resilience to natural hazards as the ability of an actor to cope with or adapt to hazard stress. Buckle et al (2001:5) added to the work by defining resilience as the capacity of a person, group or system to withstand or recover from loss. They qualify resilience as a measure of how quickly a system recovers from failures. These authors, however, highlight that "the concepts of vulnerability and resilience cannot be divorced from each other and so they are linked in a double helix" (Buckle, *et al*. 2001:6).

There is evidence in literature that not much work has been done on resilience to weather related shocks. According to Buckle et al (2001), most studies have been concerned with vulnerability, which, according to them, is defined as the susceptibility of a person, group or a system to loss. Buckle et al (2001, 6) further argue that resilience must be given priority over vulnerability "…because achieving resilience is to be positive while reducing vulnerability is reactive to climatic variations".

Phiri (2010,8) added to the discussion by agreeing with Buckle *et al.* (2001) that "resilience, just like vulnerability, is a complex and multifaceted term such that different layers and features of resilience are needed to deal with different kinds of severity and stress". An important point that Phiri (2010: 20) stresses is that "...a disaster-resilient community is an ideal community such that no community can ever be completely safe from natural and man-made hazards". This leads to the point that "a disaster resilient community is the one that is safe from all hazards or has appropriate knowledge to build in and design in a hazard context, thereby minimising vulnerability…" Phiri (2010: 20).

Alinovi *et al.* (2009) argue that the ability of a household to bounce back after being hit by a shock depends on its ability to cope with risks to which it is exposed.

Buckle *et al.*(2001) suggest that resilience is a positive attribute and does not only include lack of or reduced vulnerability. It includes attributes such as: resources, management skills, knowledge and information, access to services, involvement in decision making and planning process, equitable social arrangements, support and supportive capacity, personal coping capacity, shared community values, shared community aspirations and plans and local engagement in social, community and local government capacity.

Phiri (2010: 19) defined resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and to recover from the effects of a hazard in a timely and efficient manner". The United Nations Development Group (UNDG, undated: 38) also defined resilience of a community as "the ability of the community, society or even a household to "spring back" from a shock" These authors further argue that "the resilience of a community in respect to potential hazard events is determined by the degree to which the community has necessary resources and is capable in organising itself both prior to and in times of need". This is in line with arguments from Buckle *et al.* (2001) provided above.

Falkenmark and Rockstrom (2009:94) further provided some insights into the concept by arguing that "resilience, as it applies to integrated systems of people and nature, is the amount of change a system can undergo and still remain in the same state. Resilience shifts attention from pure growth optimisation (e.g. yield) and efficiency to the ability to adapt, recover, develop and remain flexible". In their own words, Falkenmark and Rockstrom (2009:94) show a distinction between agricultural droughts and meteorological droughts by arguing that "agricultural droughts and dry spells are primarily caused by failures in past management and potential or inability to tap potential of possible management options while meteorological droughts are climatic occurrences. Building resilience for coping therefore involves farm management efforts". It was against this argument that the study wanted to identify socio-economic factors that determine households' ability to resist, absorb, accommodate and to recover after being affected by dry spells and droughts. After analysing all the definitions of the term resilience, this study adopted and used the definition that was provided by Phiri (2010) given above to refer to the term resilience. This was because this definition was considered to be much more comprehensive within the scope of the present study.

1.5 Objectives of the study

The study attempted to answer the question "What are the main factors that enable maize farming households in Chipoka to resist, absorb, accommodate and recover from dry spells and drought?"

1.5.1 Main Objective

The main objective of the study was to determine household resilience to prolonged dry spells and droughts among maize producers in Salima district.

1.5.2 Specific Objectives

Specifically the study aimed to;

i. Determine factors that affect a household's resilience to dry spells and droughts in Chipoka EPA.
ii. Determine the effect of drought resilience on the welfare of farming households in Chipoka EPA.

1.5.3 Hypotheses

The following hypotheses were tested in the study;

i. A household's social-economic, demographic, community and farm characteristics do not affect its resilience to prolonged dry spells and droughts in Chipoka EPA.
ii. Drought resilience does not have any significant effect on the welfare of farming households in Chipoka EPA.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

There are a number of studies that have been carried out to measure impacts of natural disasters, particularly, droughts and floods in Malawi and beyond. This chapter provides a review of some of the key literature on the impacts of natural disasters and different methodologies that researchers have employed in their various studies. The objective of this review was to uncover what has already been done in the area of resilience and in the process identify gaps that the present study tried to address. The review also helped to identify key variables that have been documented to reduce vulnerability and enhance resilience among households in disaster prone areas. Before starting the review, it was considered important to provide trends in dry spells and drought in Malawi.

2.2 Historical trends on dry spells and droughts in Malawi

Malawi has historically experienced some serious floods and droughts over the past 50 years. The disasters have had significant effects on household well-being and the entire economy. The years 1948/49, 1991/92, 1993/94, 2000/01, 2001/02 and 2004/05 are some of the memorable years in the history of natural disasters in the country. The country is yet to forget the devastations and the subsequent impacts that have resulted from these disasters. The major impact of these droughts has been the drastic reduction in food production, which has resulted in starvation, migration to other countries and a sharp decline in the national economic performance in the years concerned. The reduced food production, combined with lack of coherent policies to influence national response, have been instrumental in shaping the political landscape though some disasters had little to do with the political environment at the onset.

These adverse events have also influenced the intervention of non-governmental organisations (NGOs) to team up with the government in helping rural communities to respond favourably to adverse environmental changes. The result has been the introduction of technologies that when adopted and properly used would help smallholder farmers to cope with adverse effects of these shocks. Occurrence of these shocks and their subsequent effects have encouraged some players to consider disaster preparedness and response as viable options to mitigate effects of disasters.

2.3 Empirical Studies on impacts of floods and droughts

Droughts and the dry spells have been known to have adverse effects on the welfare of the affected individuals. A study by Pauw *et al.* (2010) applied a Computable General Equilibrium Model (CGE) on the 2004/05 Malawi Integrated Household survey data (IHS) to provide insights on the economy-wide impacts of floods and droughts. The authors indicate that droughts should be seen as an abnormal event that occurs when moisture levels are far much less than the long-run average. The authors also indicate that dry spells are a short term situation of delayed precipitation, which when extended may lower the soil moisture levels and hence become droughts. According to Pauw *et al.* (2010), for an event to be declared a drought, the moisture levels must be sufficiently less than long-run mean levels.

An important point that was raised by the authors was that not all droughts have similar impacts on crop production losses because their effects depend on whether a drought occurs during a crop's growing cycle or not. This supports the argument that not all shocks have similar effects on households but that effects depend on the intensity and duration of the shock, and also the location of the farm. Onyekuru and Marchant (2014) highlight impacts resulting from climate change by identifying delay in the onset of rainfall, less rainfall, early rains followed by dry weeks, erratic rainfall patterns, uncertainty in the onset of the rainfall season, long dry season, desertification, drought, heat waves, drying of streams and rivers as some of the impacts of that have resulted from changes in rainfall and temperatures. This, they argue has affected livelihoods of many people in different ecological zones, especially in developing countries where many people depend on natural resources for their livelihood. Jury and Mwafulirwa (2002), however, argue that climatic variability over Malawi has many similarities to its neighbours. This implies that most of the adverse conditions that are being experienced in Malawi are also being experienced in its neighbouring countries. This therefore, provides an opportunity for the governments to share experiences on how to address these challenges.

The study by Pauw *et al.*(2010) suggested that smallholder farmers are the most affected by shocks. For example, Jury and Mwafulirwa (2002) report that failure of the rains for over one month in the 1992 drought reduced maize output by 50 percent and this resulted in food being imported into the country. This had negative consequences on the country's economy. In their results, Pauw *et al.* (2010) revealed that small-scale farmers are the worst affected by droughts in Malawi. Ibid indicated that "the value added generated on small farms falls to about 32.34 per cent compared to 11.24 per cent on large farms in a drought year". This observation was explained by the fact that most small-holder farmers rely heavily on maize, which is highly vulnerable to droughts as compared to other crops. Ibid also argued that poverty worsens under the various drought scenarios. The authors found that droughts alone caused losses equivalent to one percent of GDP every year, which was equivalent to US$12.1 million per annum (in 2005 prices). They argued that economic losses were higher during extreme droughts such as those that were experienced in 1991/92, where the GDP contracted by as much as 10 per cent. The higher losses experienced by smallholder farmers during droughts provided the basis for their selection in the present study.

As much as we are concerned with vulnerability of farming households, some authors have argued that vulnerability to hazards does not mean that vulnerable household can be poor. For example, Adger *et al.* (2003) argued that vulnerability to effects of climatic variations is not strictly synonymous to poverty. Much as this argument may be true in the general sense, in the context of most African countries, particularly in Malawi and other Least Developing Countries (LDCs), the argument may not necessarily hold because most livelihoods are agricultural based. This means that any situation that may interfere with utilisation of natural resources may have big implications on the welfare of farming households.

2.4 Household and Livelihood Security

Apart from drought, it has been documented that farmers are faced with different vulnerabilities. For example, Swift and Hamilton, (2003) have argued that food security at household level arises from several causes and that adverse effects are more devastating to a given household if more than one cause affects the household at the same time. Drought has been identified as one of the most common forms of environmental risks, together with diseases such as HIV/AIDS and malaria that have affected most parts of developing countries, including Malawi. In the case of Malawi, Nangoma (2007) argues that rural communities are facing chronic food deficits owing to effects of floods and droughts. This, he argues, is a major concern to the government because of the far reaching consequences on food, water, health and energy. The unreliability of markets in most developing countries has also been identified as one of the major causes of chronic food insecurity which usually stems from low farm output, resulting partly from unreliable climatic conditions of which droughts are an example. This means that despite this study focusing on dry spells and drought, smallholder farmers in developing countries are faced with multiple challenges, but in most cases they are unable to cope in extreme cases. However the study chose to focus on dry spells and droughts because of their increase in frequency over the past three decades. Since farmers are not passive in responding to events that threaten their livelihood, Onyekuru and Marchant (2014) identified agroforestry, irrigation and use of energy saving stoves to reduce pressure on forests as some of adaptation strategies that rural livelihoods have adopted.

2.5 Effects of drought on urban consumers and rural non-farm households

Occurrence of adverse environmental events, such as drought and floods in rural farming communities has been known to have trickle down effects on urban and rural non-farm households in several ways. The most direct effect is through reduced farm output, which results in high food prices for urban consumers, while rural based non-farm households are affected by reduced demand for farm labour that arises from reduced areas planted on the farm, although this depends on the time of the year a drought or dry spell occurs. This results in increases in food insecurity among urban poor and non-farm rural based households. The common feature between the two groups of households (urban consumers and rural non-farm households) is their dependence on markets for food such that prices and income are some of the major factors that influence the food security status of such households. Urban consumers and rural non-farm households are thus, vulnerable to changes in prices for food and their sources of income, which in turn affect their food purchasing power and hence their food security situation. Inefficiencies in food supply and purchasing patterns among poor households themselves mean that poor households pay higher unit prices for food as compared to their rich consumer counterparts who buy in bulk and pay lower unit prices (Swift and Hamilton, 2003). In order for urban households to be food secure, their incomes must be large and consistent enough to feed their households. This highlights that occurrence of droughts affects not only rural farming households but also other sectors of the economy, including urban consumers.

2.6 The effects of disasters on socio economic development

There has been increasing interest in studying dry spells and droughts because of the effects such events have had on the economy. Most of the effects of dry spells and droughts have been negative on the effected groups. For example, Pauw, *et al* (2010) highlight that drought affects production levels by reducing the size of the area planted and/or reducing crop yields through crop failure. The authors indicated that farmers are not passive but rather active in the way they respond to droughts and dry spells. According to them, farmers reduce the amount of land allocated to crop production if the drought or dry spell takes place at the sowing season while if the drought/dry spell hits at flowering stage, there is very little that farmers can do and hence their output levels are affected. This shows that there is a limit up to which farmers can mitigate the effects of dry spells after planting. In line with this Pauw *et al.* (2010) indicated that the severity of droughts is not constant and the effect on crops depends on the time of the cropping cycle at which dry spells/droughts strike. Because of this, Ibid argued that there is no statistically sound way in which to represent losses from dry spells and droughts and consequently, any drought losses are attributable to yield losses.

Other studies have revealed that size and structure of the affected economies matter in the way the experience effects and how they respond to shocks. For example, Pelling *et al.* (2002) argued that the impacts of disasters are shaped by the size and structure of the receiving economy as well as the triggering event. They highlighted that small and poorly diversified economies, such as that of Malawi with spatially concentrated productive assets, are particularly vulnerable to economic and natural shocks. Pelling *et al.* (2002) also argued that disasters may contribute towards longer term challenges on the economy such as balance of payment deficits. They argue that disruption of domestic production is most likely to halt exports while demand for domestic goods is most likely to remain high and thus the economy tends to import more and export less thereby creating a balance of payment deficit. The increased balance of payments deficits may force the governments to continue borrowing which may have long term debt servicing and economic growth effects. They also argue that economic growth is most likely to decline in the after math of disasters through loss of infrastructure and productive assets and economic opportunities forgone. The authors also highlight that some disasters such as floods may provide stimuli for growth in the post disaster recovery period. This, according to Pelling *et al.* (2002) may result in a temporary boom which may result in a temporary economic growth. They give an example of reconstruction of damaged infrastructure that was damaged by floods which may result in economic growth. This may, however, depend on how quick the receiving economy is to recover by investing in reconstruction, which also depends on the size and structure of the affected economy. Economies that are faced with perpetual fiscal deficits such as that of Malawi are less likely to respond and so disasters may not result in any short or long term gains to the economy but exacerbate the economic challenges that the economies face.

Pelling *et al.* (2002) also indicate that in hazard prone districts and countries, development potential may be depressed due to an increase in government funding to disaster mitigation and reconstruction after occurrence of the actual disaster. Disasters also result in reduced revenues from reduced economic activities due to the events. This, they argue, exacerbates inequalities in economic development. The authors also argue that disasters act as a disincentive to investment especially to new investors during reconstruction when perceptions of hazards are heightened and the economy is unstable. This study did not concentrate on macro-economic effects of dry spells and droughts but rather focused on micro-economic effects by looking at what factors enhance resilience among households affected by dry spells.

2.7 Categorisation of droughts

Dry spells and droughts have been classified into two by Falkenmark and Rockstrom (2009: 94) as meteorological and agricultural. This has been done to enhance our understanding of the concepts. The authors identify meteorological dry spells as those that occur less than twice in three years, caused by a rain deficit of 2-5 weeks and results in yield reduction. They also identify agricultural dry spells as those that occur more than twice in three years, caused by poor rainfall partitioning leading to low plant availability and poor plant water uptake capacity and results in yield reduction or complete crop failure.

Meteorological droughts, on the other hand are defined by Falkenmark and Rockstrom (2008, 94) as those that occur once in a decade, caused by seasonal rainfall below the minimum crop water requirement and result in complete crop failure. Agricultural droughts are defined as those that occur more than once in ten years, caused by poor rainfall partitioning and leading to seasonal moisture deficit to produce harvest and also leads to complete crop failure.

Table2.1 below was adapted from Falkenmark and Rockstrom (2008), to provide the distinction between meteorological and agricultural dry spells and droughts.

Table 2.1 Differences between meteorological and agricultural dry spells and droughts

	Dry spell	**Drought**
Meteorological	**Occurrence**: Less than two in three years **Impact**: Yield reduction **Causes**: Rainfall deficit of 2-5 week period during crop growth	**Occurrence**: Once in ten years **Impact**: Complete crop failure **Cause**: Seasonal rainfall below minimum seasonal plant water requirement
Agricultural	**Occurrence:** More than twice in three years **Impact**: Yield reduction/ complete crop failure **Cause**: Poor rainfall partitioning leads to low plant water availability. Poor plant water uptake capacity	**Occurrence**: More than once in ten years **Impact**: Complete crop failure **Cause**: Poor rainfall partitioning leads to seasonal soil moisture deficit to produce harvest

Source: Adapted from Falkenmark and Rockstrom (2008)

The authors argue that meteorological droughts are climatic occurrences while agricultural droughts are management related occurrences.

In terms of measurement, different authors have suggested different criteria for measuring dry spells and droughts. Pauw *et al.* (2010) indicate that different indices exist to facilitate the identification of droughts. According to these authors, these indices vary from simple to complex ones. Most of these indices, according to these authors, use precipitation and evaporation (or temperature as a proxy) to identify the droughts. An example of simple indices is the Standard Precipitation Index (SPI) which was developed by McKee, Doesken and Kleist (1993), which uses precipitation data only. The authors also indicate that use of the SPI is justified on the basis of its simplicity and flexibility. They also highlight that the index permits measurement of the drought's duration, intensity and severity. The authors indicate that in order to measure the impacts of the droughts on crop output, regression models are used to describe the statistical relationship between droughts of different severities and associated crop losses. Production losses are calculated as the difference between the actual realised (observed) yields and the expected yields, which is taken as the closest crop production achieved during the most recent normal year. Exposure and hence risk to a natural shock depends on several factors such as severity of the weather event, location of farmers and their cropping patterns.

2.8 The Return Period of a dry spell or drought

In studies involving climatic events, including the present study, it is important to consider the return period of the event under consideration. The return period of a climatic event is the expected time period that occurs between two climatic events of the same severity. The return period of a drought or any other climatic event is used to measure its severity. A drought that has a high return period is the one that has high severity but has a lower probability of occurring, (Pauw *et al.*, 2010). From this definition, it would also mean that a drought that has a shorter return period is the one that has less severity but has a relatively higher probability of occurrence. According to Pauw *et al* (2010), the probability of occurrence can be represented by the exceedance probability, which is the inverse of the return period. Most frequently studied return periods are in 5, 10, 15, 20 years and so on. A drought that has a longer period before it occurs, for example 20 years, is said to have a higher return period than a drought that takes five years before it occurs again. Since dry spells are frequent in the area, a five year return period was used in the study.

It is important to bear in mind that despite having an idea about the return period of a drought, occurrence of a drought is a stochastic process and so future occurrence of drought is an uncertain event, making it difficult for short to medium term interventions. However, the frequency of dry spells, droughts and other natural shocks have increased over the last decades (Phiri, 2010) and so it has become important to respond to this phenomena by putting in place disaster risk reduction (DRR) mechanisms.

2.9 The sustainable livelihood approach to poverty analysis

Most studies that are concerned with poverty assessments do so using livelihood approaches, most of which are similar but differ in some respects. In simple terms, a livelihood is a means of making a living. A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for earning a living, (Chambers and Conway, 1992 in Krantz, 2001). There are many frameworks that have been proposed to enhance our understanding of how households cope with shocks. One of the most dominant frameworks has been the sustainable livelihoods framework. The sustainable livelihood approach is an analytical framework that is used to understand household crises as they relate to food security. The approach is an improvement and generalisation of Sen's(1981) entitlement approach which was used to understand famine and was very influential during that time. The entitlement approach proved to be a useful tool in understanding food insecurity and directing attention to policies to remedy it. Despite its popularity, some authors criticized the entitlement approach, for example Devereux (1993a) and Swift (1989a) indicated that entitlements are less clear in real life than proposed by Sen. These authors argued that the entitlement approach adopted a passive view of food insecure households and individuals, giving little prominence to the endogenous and sometimes effective strategies that households adopt. The approach assumed a "*food first*" mentality among food insecure households, ignoring trade-offs that households make between choosing to have food and /or holding on to their assets.

Under the sustainable livelihood framework, a livelihood is said to be sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base. The sustainable livelihood approach is an analytic framework, which seeks to improve our understanding of how people use resources at their disposal to construct a livelihood (Swift and Hamilton, 2003). According to Swift and Hamilton (2003) the sustainable livelihoods approach gives attention to contextual and institutional settings which frames livelihood options. It also considers multiple types of capital available as resources out of which a livelihood can be constructed and its understanding of livelihood strategies as multiple and dynamic which households face.

The approach also allows a wide range of influences to be used into a single frame of analysis. Sustainability means both the ability of the livelihood system to deal and recover from shocks and stress by means of coping (short term) or adapting (long term change in livelihood options) and also the ability of the livelihood system to use the natural resource base on which it depends or enhance productivity over time. This approach shows that food security is not just an issue or even the sustainability of production or entitlement but depends on how people, especially poor people gain access to production and exchange of food. Some authors, such as Devereux (2001) have argued that it is important to pay attention to contextual settings in which livelihoods are constructed since development and change is path-dependent, meaning that previous events may define or limit the degree to which present or future options are available.

This means that despite being useful, it is important to apply the sustainable livelihood approach in the specific context of the study area under consideration.

2.10 Past studies on resilience

There are a number studies on resilience that the present study benefited from. A summary of some key related work that helped in selection of variables in the present study is now presented. First, a study by Keil *et al.* (2006) was aimed at identifying determinants to El Nino Southern Oscillation (ENSO) related drought in Central Indonesia. The study used the Principal Components Analysis (PCA) to aggregate consumption and production related indicators into the resilience index, which was used as a measure of resilience. In their study, it was found that farmers faced a substantial risk due to drought. It was established that possession of easily liquidated assets, high levels of technical efficiency, access to credit, household size and number of organisations were some of resilience enhancing factors. Despite these factors the authors indicated that farmers were vulnerable to adverse effects of droughts.

Another study relevant to the subject matter was conducted by Tesso *et al.* (2012) who analysed the vulnerability and resilience of farm households in North Shewa Ethiopia. The analysis was based on agro-ecological classification of the zones in order to analyse vulnerability to climate change induced shocks. A vulnerability index was calculated using the Principal Components Analysis (PCA). Ordered probit model was used to identify determinants of resilience and it was found that better investment in natural resource management, better social network, access to credit, preparedness, saving liquid assets, access to irrigation and better education were some of the factors that enhanced resilience after climate change induced shocks.

Alinovi *et al.* (2009) measured resilience of Palestinian households using the Principal Components Analysis (PCA). Then a regression model was used to determine the role of the resilience index on vulnerability to food insecurity. The key finding from this study was that vulnerability to food insecurity depends on the household's exposure to such risks and resilience. Some of the notable factors that were identified to enhance resilience were income, food access capacity and social safety nets.

Another study that addressed the subject matter was conducted by Andersen and Cardona (2013) who proposed a simple way of measuring livelihood diversification. Regression analysis was used to identify factors that were associated with higher vulnerability and resilience. Their results revealed that the most important strategy for resilience was to have a working spouse in the family. The study also identified age of the household head as the second most important factor. Most interesting from this study was the revelation that urban households were found to be more vulnerable to adverse shocks compared to rural households.

The four studies provided above provide most of the reference on the methodology and selection of variables that were used in the present study. It must be borne in mind, however, that the variables and methods were adjusted appropriately to suit the context of this present study.

2.11 Summary

This chapter provides a review of some of the work related to vulnerability to natural hazards and resilience of the affected systems or households. During the review process, factors that enhance resilience of a farming household to natural hazards were identified and some of them were adopted into the present study. It is important to acknowledge, at this stage, that some of the present study adjusted the methods and measurement of some variables as was considered appropriate to the context of the study.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter presents the methodology that was employed in the study. The chapter begins by providing the conceptual frame work, followed by the study area. Following that will be the sampling technique that was employed to identify respondents. Following this, a discussion of methods that were used to analyse data is provided. The main aim of the analytical methods employed was to construct the drought resilience index and use it to measure the effect of resilience on the welfare of farming households in Salima. The chapter also provides descriptive statistics on socioeconomic, demographic, community and farm characteristics of respondents.

3.2 The conceptual framework

3.2.1 Drought Risk Assessment Model

The drought risk assessment model is used to quantify losses resulting from droughts and dry spells. According to the World Bank (2010), the drought risk model was designed to quantify drought induced agricultural losses that could be estimated using appropriate hydrological and meteorological proxy indices, together with historical drought losses. The model realises that modelling drought is a complex process because of the slow onset and concealed nature of drought, making it difficult to quantify the direct and indirect economic losses (World Bank, 2010). The drought risk assessment model comprises of four elements namely; hazard, exposure, vulnerability and loss. The elements are now briefly discussed.

3.2.2 Hazard Analysis

This component is concerned with describing the nature of the event the exposure is subjected to, that cause damage to life and property (World Bank, 2010). The process of hazard analysis comprises of three basic variables of severity, frequency and locations of future occurrence (World Bank, 2010). In the context of drought, the hazard variables are drought severity, drought frequency and potential occurrence of a drought of a given intensity. Data for drought years is usually used to generate return periods for droughts of different intensities. The World Bank (2010) defined a meteorological drought as seasonal cumulative rainfall (November-March) falling below 75 percent of the long term (40 year) average recorded at each weather station.

3.2.3 Exposure Analysis

Exposure is concerned with describing the geographical distribution of assets at risk from the area of interest and categorizes them based on their damageability potential to the hazard under consideration. In terms of exposure to droughts and dry spells, agriculture is the largest sector in Malawi and maize alone takes over 56 per cent of total land area allocated to crops (World Bank, 2010). It has been established by the World Bank study (2010) that maize is the most preferred food crop that is grown in all regions of Malawi. This crop was chosen for the study because of its importance to the food security status of the country and the general multiplier effects it has to the entire economy.

3.2.4 Vulnerability Analysis and Losses from the drought

According to World Bank (2010), modelling vulnerability of natural hazards to a system involves establishing the relationship between the potential damage from extreme exposure to the hazard and different levels of the hazard. The degree of rainfall deficiency represents the intensity of the drought or the hazard while the magnitude of loss in crop output represents the potential damageability of the crop.

It is important to remember that drought damage to crop yield is a complex process that can result from different atmosphere-soil-crop interaction of the timing of moisture stress, its magnitude, its persistence and the number of times the event recurs in the growing season. Yield can be affected through either a reduction in crop area cultivated due to deficient rainfall or the lowering of crop yield due to deficient rainfall during subsequent growing stages of the crop.

3.2.5 Dry Spells/Drought risk to maize output

It has been noted that the level of damage to crops is not uniform but depends on the type of crop and time of the season by which the crop has been subjected to moisture stress (World Bank, 2010).

A publication from FAO (undated) indicates that maize is relatively tolerant to drought during vegetative and ripening growth stages. The article indicates that the maize crop is particularly vulnerable to drought and moisture stress during flowering (tussling and silking) stage and so rainfall is most critical in Malawi in the period from late January to early March during which maize reaches its flowering stage. Yield reductions are, therefore, more likely to be severe if the dry spell hits during this critical period.

3.2.6 The Drought Resilience Model

The empirical model used in the study was adapted from the work of Alinovi *et al.* (2009), who based their work on the asset based approach to social risk management.

Figure 3.1 below shows the conceptual framework, which provides the rationale for measuring household resilience to endogenous and exogenous shocks:

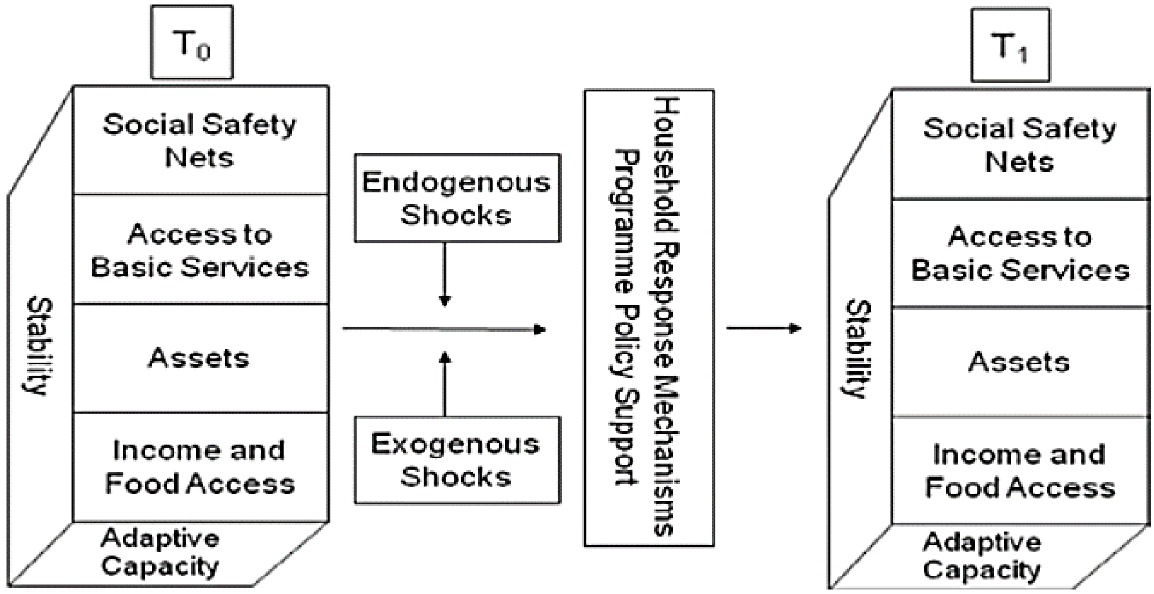

Figure 3.1 Household resilience conceptual framework

Source: Adapted from Alinovi *et al.* (2010)

In Figure 3.1, endogenous shocks are those that a household can induce or influence while exogenous shocks are those that a household has no control over and just receives them as they come. This model assumes that resilience of a given household at a given time, T_0 depends primarily on the options available to that household for making a living (Alinovi, *et al.*, 2009). These options affect the response of the household to adverse occurrences i.e. influences the household's ability to respond to a shock that a given household is exposed to. Alinovi *et al.* (2009) indicate that some of the options available include a household's access to assets, income generating activities, public services and social safety nets. At each time period, T_i each component is estimated separately to generate a composite score (index) of household resilience (Alinovi *et al.*, 2009). Another important element shown in the figure is stability, which represents the degree to which household options vary over time. Households whose options are stable and have a high adaptive capacity are said to be more resilient than those whose options are unstable and have less adaptive capacity. According to Alinovi *et al.* (2009), the resilience index for household $i$can be expressed implicitly as:

$$R_i = f(IFA_i, A_i, ABS_i, SSN_i, S_i, AC_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

where: R_i= Resilience Index for household i, IFA_i= Income and food access for household i,A_i= Asset base for household i,ABS_i= access to basic services for household i, SSN_i= Social capital for household i, S_i= Stability for household i (degree to which options vary over time) and AC_i= Adaptive capacity for household i.

It is important to notice that resilience is a latent variable since it is not observable in the study and so it can be estimated by estimating the different components of the function, some of which are themselves latent variables, which can be estimated through multivariate techniques (Alinovi *et al.*, 2009).

3.3 Study Area

The study was carried out in the central lake shore district of Salima. Salima town lies about 103 kilometres to the east of Lilongwe, the capital city of Malawi. The district has a total land area of 2,196 square kilometres or 2.3 percent of the land space for Malawi. It is bordered by Nkhotakota to the north, Ntchisi to the north-west, Dowa to the West, Lilongwe to the South-West, Dedza to the south and south and Lake Malawi to the east (GoM, 2006). Figure 3.2 below shows map of Salima district and Chipoka Extension Planning Area, where the study was conducted.

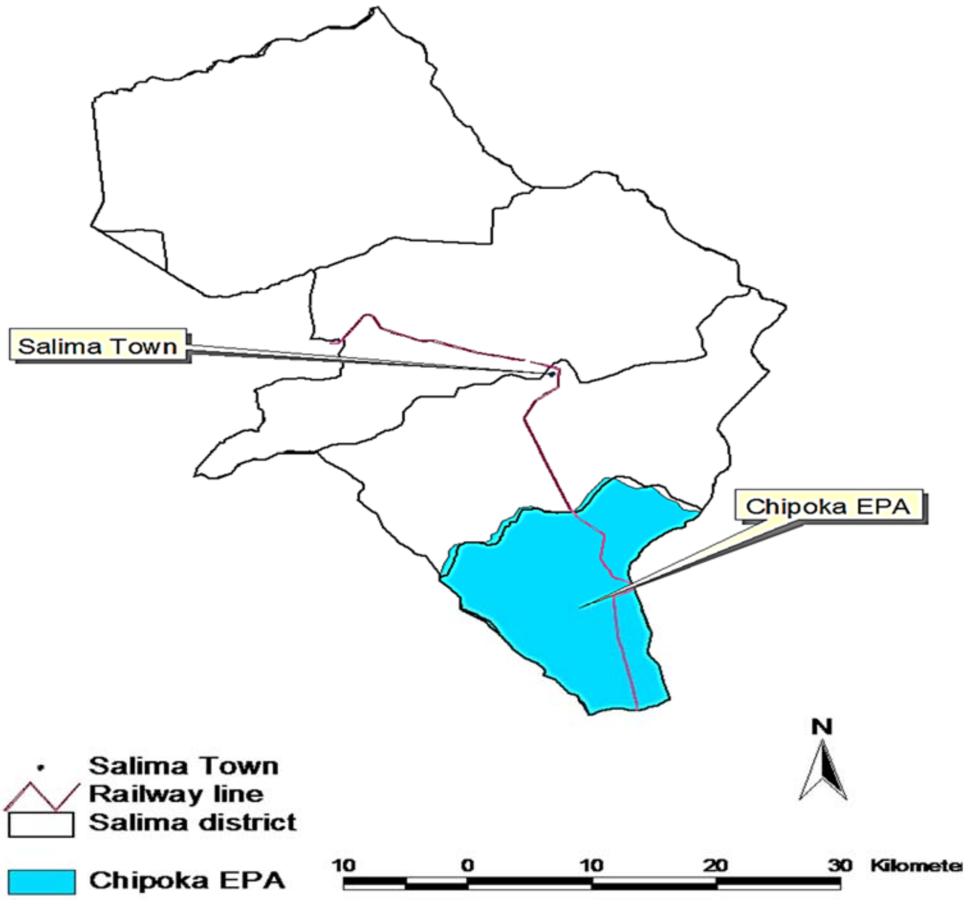

Figure 3.2 Map of Salima district showing the location of Chipoka EPA

Source: Designed for the study by L.A.G.O.Sibande

Salima district was selected because it lies along the rift valley, which is among areas worst affected by adverse effects of climatic variations, particularly prolonged dry spells and drought despite the potential of using the fresh water from lake Malawi, present in the district, to irrigate crops to mitigate the adverse effects of dry spells and droughts.

3.4 Data sources and type

The study used both qualitative and quantitative primary data. The main thrust of the study focused on quantitative data that was collected on smallholder farmers in Salima district. Primary data was collected mainly using semi-structured questionnaires. Key informant interviews were used to provide explanations to the findings of the quantitative analysis. Specific attention was paid to find out how rural people use social networks to invest in each other as micro-insurance from weather related risks. Attention was also paid to learn how rural based farming communities have responded and adapted to climatic variability, which has been one of the key issues that has affected farmers in the study area.

Quantitative data was used to estimate the Drought Resilience Index (DRI) for each of the households that participated in the study and to identify key factors that determine its influencing factors. Realising that quantitative analysis lacked explanations on some of the interesting findings, qualitative data was collected to provide such explanations and insights that lacked in the quantitative analysis.

3.5 Sampling Procedure

The data used in this study were based on a household survey conducted in Chipoka Extension Planning Area (EPA), in the Southern part of Salima district. Chipoka EPA covers Traditional Authorities Ndindi and Kambalame. The area was selected because it is one of the driest areas in the district. This is because the area experiences dry spells on a frequent basis. Salima district lies within Salima Agricultural Development Division (ADD).

The household survey data were collected in the month of July, 2014 and key issues that were common during the interviews were recorded as case studies that helped to explain the results. A multi-stage sampling procedure was used to identify respondents to the study. The sampling frame comprised a list of all the twelve sections and thirty two villages from the area was obtained from the EPA offices at Chipoka. From this list, five sections were randomly selected and from these sections, twelve villages were randomly selected to participate in the study. To determine the number of respondents for the study from each village, the Probability to

Proportion Sampling (PPS) technique was employed to come up with 427 respondents for the study. Design effect was taken care by stratifying the sample into sub-groups which were villages in this study. The collected data were taken to Bunda College for entry in the Statistical Package SPSS. The data were further cleaned and analysed in STATA 12. The sample size for the study was determined using the following formula;

$$n = \frac{z^2}{e^2} \frac{p.q.N}{(N-1) + z^2.p.q} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2)$$

where; n was the sample size to be determined, p was the proportion of farming households that are resilient to dry spells. This proportion was unknown, so a proportion of 0.5 was used, q was the proportion of farming households not resilient to dry spells. Since this proportion was also unknown, the proportion of 0.5 was used. Z was the number of standard deviations at a given confidence level (i.e. 95 per cent in this study), e was the acceptance error (0.05) and N was the population size (16,563 farming families). Substituting the values into the formula above yielded a sample size of 384. After adjusting for non-response a sample size of 427 respondents was determined.

Using the formula presented above the sample that was used in the study was distributed as shown in table 3.1 below:

Table 3.1 Distribution of the sample

Traditional Authority	Section	Village	Sample
Ndindi	Chimoga	Karonga II	47
Ndindi	Chimoga	Chimoga	18
Ndindi	Mchoka	Kandeu	50
Ndindi	Mchoka	Kuntupa	31
Ndindi	Mchoka	Mzwenene	23
Kambalame	Mpitilira	Mkweche	25
Kambalame	Mpitilira	Njirika	21
Kambalame	Mpitilira	Manda	55
Kambalame	Kalekera	Kapichi	20
Kambalame	Kalekera	Mfuti	53
Kambalame	Chitontho	Malendo	50
Kambalame	Chitontho	Mbalame	36
Total			**427**

A sample of 427 respondents was considered to be optimal bearing in mind that the study was conducted in one EPA and that the sample was proportional to the total number of farm families in the area.

3.6 Empirical Model for measuring drought resilience and impacts of droughts

The term resilience was used in this study in line with Phiri (2010) to refer to the ability of a farming household exposed to hazards to resist, absorb, accommodate and to recover from the effects of a hazard in a timely an efficient manner. Keil et al. (2006) indicate that, among other things, household risk management aims at smoothing consumption in the affected household, therefore, resilience was measured as the observed degree of production and consumption of home produced maize.

To capture the effect of dry spells and droughts on consumption of home produced food an account was made on the absolute differences on selected food items between normal and drought situations. Keil *et al.* (2007: 2) argue that “the share of expenditures relative to normal situations is expected to be positively correlated with household drought resilience.” They also indicated that “differences in food consumption between normal and drought situations are expected to be negatively correlated to drought resilience, in the case of superior foods and positive in the case of inferior foods.” According to these authors, a household was considered to be fully resilient if all indicators remained unaffected.

3.6.1 Empirical model for estimating resilience of a farming household

In order to identify a household as either resilient to dry spells or not, Principal Components Analysis (PCA), a multivariate analysis technique, was used to aggregate four production and consumption related indicators into the drought resilience index (DRI).Principal Component Analysis is a variable reduction technique that aims at reducing a large set of variables into a smaller set of “artificial” variables called principal components. These principal components account for most of the variance in the original variables. Some authors have defined principal component analysis as a linear combination of optimally weighted observed variables (Holland, 2008). In order for principal component analysis to work properly, a number of assumptions must be met; these assumptions are now presented next.

Assumption number one: Interval-level measurement

This assumption requires that all variables that should be analysed should be assessed on an interval or ratio level of measurement. Some researchers have also extended this assumption to measuring ordinal variables, especially those that are measured on an ordinal scale.

Assumption number two: Random Sampling

This assumption requires that each subject must contribute one score on each of the observed variables. The sets of scores that must be used in principal component analysis must represent a random sample drawn from a population of interest.

Assumption number three: Linear relationship between variables

This assumption requires that there must be a strong linear relationship between a set of variables that measure the same construct and a weaker linear relationship between variables that measure different constructs. The reason for this assumption is because principal component analysis is based on Pearson correlation coefficients which requires a stronger linear relationship between variables. A correlation matrix was run to show the linear relationship among variables and is presented in the results. In order to prove that the variables are correlated with one another, the Bartlett's test of sphericity is run on the data. According to Friel (undated), the aim of this test is to test the hypothesis that variables are not inter-correlated and that non-zero correlations observed in the data set are due to sampling error. By this procedure, failure to reject the stated null hypothesis would mean that there are no stronger linear relationships among the variables and so the data cannot be used for principal components analysis, while rejecting the null hypothesis means the data can be used for principal components analysis. Rejecting the null hypothesis allows the researcher to use the data for dimension reduction, which means that the variables can be aggregated into a single variable using statistical techniques.

The Bartlett's test of sphericity calculates the determinant of the sums and cross products from which the inter-correlation matrix is derived. The determinant of the inter-correlation matrix is then converted into a Chi-square statistic which is tested for significance. Results for this procedure are presented in chapter four.

Assumption number four: Sampling adequacy

Sampling adequacy means that the sample size used is large enough to allow for principal components analysis. This assumption means that in order for principal components analysis to give reliable results, large enough sample sizes must be used. Different researchers have provided different rules for determining sampling adequacy but the most commonly used measure of sampling adequacy is the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, which required that the overall KMO should be at least 0.5 for the sample to be considered adequate for PCA. The Kaiser-Meyer-Ohlin was run on the data and is presented in chapter four.

Assumption number five: Normality

This assumption requires that the data must be normally distributed. Variables that demonstrate skewedness must be transformed so that they approximate normality. This assumption also requires that there must be no outliers in the data. To ensure that normality is achieved in the data, all variables were standardised by subtracting the value of the mean from the value of each observation.

If all the assumptions are met, principal component analysis is applied on the data to generate weights that are later used to generate new variables. In order to determine the number of components to retain and use for variable generation, the selected components must first of all account for larger variance in the data and then must have appropriate signs that meet the apriori expectations of the researcher. In the present study, four variables were used in the principal component analysis. The selected variables were the amount of maize produced by smallholder farmers in a normal year without dry spells, the amount of maize produced in a bad year, with a dry spell, number of months a household has food produced by the household in a normal year and number of months a household has food produced by the household in a dry spell year. Table 3.2 below shows descriptive statistics for these variables;

Table 3.2 Descriptive statistics for variables used in constructing DRI

Variable	Unit	n	Mean	Std. Dev.
Maize production in a normal year	Kg	427	544.97	453.49
Maize production with dry spells	Kg	427	284.53	276.86
Number of months consuming farm produced maize in normal year	Number of months	427	8.46	2.81
Number of months consuming farm produced maize in bad year	Number of months	427	4.61	2.65

Table 3.2 above shows that the average amount of maize produced by a farming household in a normal year is about 545 kilogrammes of maize per season for an average household comprised of about 6 members. This translates to about eleven 50 kg bags per farming household. A large standard deviation of 453 tells us that the range of maize production is very wide, meaning that some farming households produce far much less output than the mean production presented while others produce far much more output than the mean farm production presented above.

Similar trends can be seen in maize production under dry spells where the average farm production of maize reported a drop to about 284.5 kilogrammes (slightly over five 50 kg bags) per farming household. The standard deviation of 276.87 indicates that there is even more variability in farm output in maize production under dry spells than in a normal year. This is not surprising because dry spells do not affect farming households in the same way because farm plots are located in different locations within the villages. Even when a dry spell affects a larger proportion of farming households, their response to the adverse effects are not the same, hence a big variability in farm output during dry spells as compared to the normal year. This entails different responses to dry spells among the farmers.

The table also shows that the average number of months farming households remain with home produced food in the normal year is about 8.5 months. More interesting from the table under this section is the observation that some farming households reported that even in a normal year, they do not produce enough amount of maize to last them for one month. These households reported that they do not have access to inputs to produce their own maize. In some cases, farmers reported that they prefer to do piece works than work on their land in order to survive during the lean months. As can be seen in the table, the average number of months a household remains with home produced food drops to about 4.6 months in a bad year.

It is important to bear in mind that the 2013/14 farming season was generally a good year in the study area as there were no significant reported cases of dry spells in the area. Farmers made reference to the 2011/12 and 2012/13 farming seasons to provide responses regarding effects of dry spells on their farm production. The four indicators were aggregated into the drought resilient index using the formula:

$$DRI = w_n p_n + w_d p_d + w_{cn} m_n + w_{cd} m_d \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where;DRI represents the drought resilience index; $w_n p_n$ represents the weight for maize production in a normal year multiplied by the actual amount of maize produced in a good year; $w_d p_d$ represents the weight for maize production in a bad year multiplied by the actual amount of maize produced in a bad year; $w_{cn} m_n$ represents the weight for number of months a household remains with home produced food multiplied by the number of months the household consumes home produced food in a normal year, and $w_{cd}m_d$ represents the weight for number of months a household remains with home produced food during dry spells multiplied by the actual number of months a household remains with food in a bad year.

The Principal Components Analysis (PCA) was applied on the data to come up with the eigen values, which were used as weights for each of the variables that were later used to generate the drought resilience index for each farming household. The Principal Components Analysis is a statistical technique that uses an orthogonal transformation to convert a set of correlated variables into a set of linearly uncorrelated "artificial variables" variables called principal components, which account for most of the variance in the observed variables. Principal components analysis is used when some of the variables under consideration are correlated with one another. The results of Principal Components Analysis are usually used as inputs for further analysis. In simple terms, PCA can be defined as uncorrelated linear combination of variables whose variances are as large as possible. In PCA, the number of principal components is the same as the number of variables used for the linear combination. Usually, the first few principal components are the ones that have the large variances. The first principal component has the largest variance, the second has the second largest variance and so on. In principal components analysis, there are a number of terms that are used. Some of the most commonly used terms are now defined.

The first important terminology is principal components or simply components. This can be defined as a linear combination of optimally weighed observed variables. The expression for a principal component can be similar to that of a regression model.

Dimension reduction is another term that is commonly met in principal components analysis. It is defined as the process of reducing a large number of random variables into one or a smaller number of variables. Principal components analysis is just one of the methods of dimension reduction. Other methods of dimension reduction include Fisher's linear discriminant, Independent components analysis and multi-dimensional scaling.

A component loading is a correlation coefficient between the rows and columns in a table of principal components analysis. Squaring the component loading gives the percent of variance explained by a given component.

In principal component analysis the terms eigen value and eigen vector are also commonly used. An eigen vector, sometimes referred to as a characteristic vector of a square matrix, **A** is a non-zero vector, $\boldsymbol{x}$, that when multiplied with the matrix yields:

$$\boldsymbol{Ax} = \lambda \boldsymbol{x} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

This means that $\boldsymbol{x}$ is an eigen vector for matrix **A,** and λ is an eigen value for the same matrix.

The Rho value of a principal component analysis is the total variance that is explained by the variables used in the analysis. It the value of Rho is 1 it means that all variance in the observed variables was explained by the components in the analysis.

Another term commonly encountered in principal components analysis is trace. This is the sum of the values on the diagonal of the correlations matrix for variables that are used for dimension reduction. In most cases the value of the trace equals the number of variables to be used in dimension reduction.

Before running the principal components analysis, all variables were expected to correlate positively with drought resilience. This was because an increase in any one of the variables above was expected to be associated with improvement in the well-being of the farming household.

3.6.2 Model for establishing determinants of household resilience to dry spells and drought

In order to test the first hypothesis, the probit regression procedure was used to identify factors that determine resilience among farming households in the study area. The drought resilience index, which was generated using the principal components analysis was used as a criteria for identifying a household as either resilient to dry spells or not. The probit regression model was considered to be the best model to apply on the available data in order to identify socioeconomic, demographic, community and farm factors that affect resilience of farming households. The model was chosen after Tesso *et al.* (2012) who used the ordered probit regression model to analyse and identify determinants of household resilience to climate change induced shocks in North Shewa, Ethiopia. In this study we assumed a latent variable model presented by Long and Freese (2001). The model assumes a latent variable y^* that is in the range from -∞ to +∞ which is related to the observed independent variables, x by the structural equation:

$$y_i^* = x_i\beta + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where: i indicates the observation; β represents parameters to be estimated and ε represents the random disturbance term. For one explanatory variable, the notation can be simplified to;

$$y_i^* = \alpha + \beta_1 x + \varepsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The equations presented above are similar to the linear regression equations with the important difference that the dependent variable is not observed (Long and Freese, 2001). According to these authors, the link between the observed binary variable y and the latent variable y^* is made with a simple measurement equation:

$$y_i = \begin{cases} 1 \; if \; y^* > 0 \\ 0 \; if \; y^* \leq 0 \end{cases} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. \dots.. (7)$$

where cases with $y^* > 0$ are observed as $y = 1$ whereas cases with $y^* \leq 0$ are observed as $y = 0$. The idea behind the latent variable is that it generates a tendency of behaving or responding in a particular way to a given situation. In this study the idea behind a latent variable is to be resilient against adverse effects resulting from dry spells and drought. While it is not possible to directly observe resilience to dry spells, a change in the latent variable is most likely to result in a change in observable characteristics. Figure 3.3 below shows the relationship between a latent variable $y^*$and the probability that a given observation possesses an attribute.

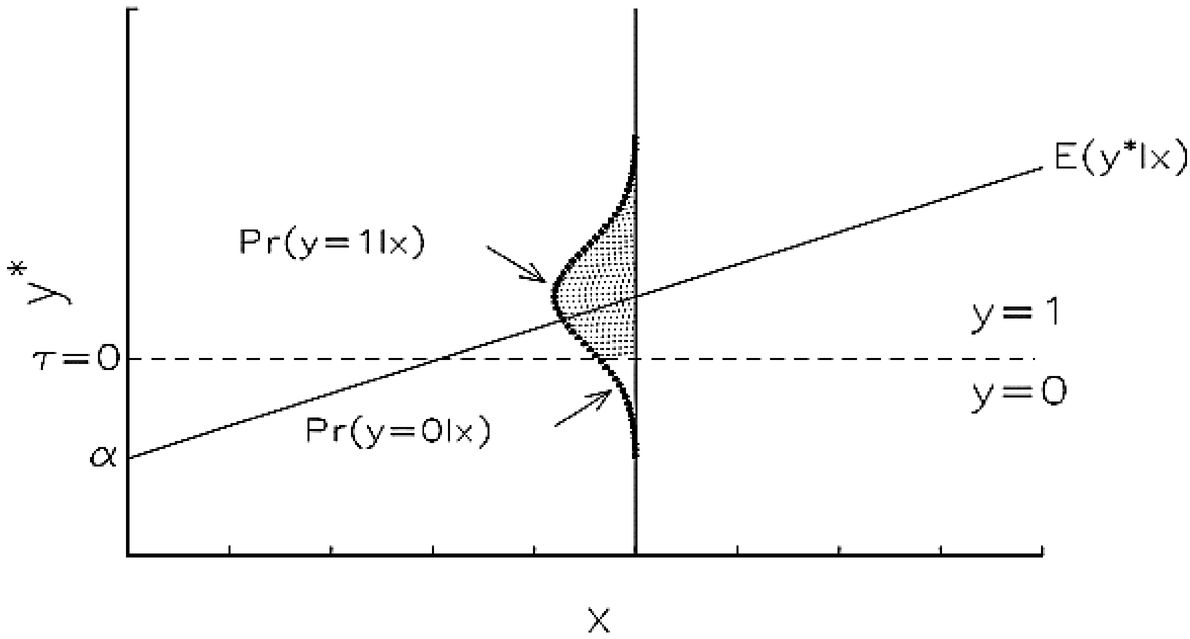

Figure 3.3 The relationship between a latent variable y^* and Pr(y=1)

Source: Adapted from Long and Freese (2001)

From the figure above, it can be noted that;

$$Pr(y = 1|x) = \Pr(y^* > 0|x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots.(8)$$

Substituting the structural model and rearranging yields the following equation;

$$\Pr(y = 1|x) = \Pr(\varepsilon > -[\ \alpha + \beta x]|x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots.(9)$$

Equation (7) above shows that the probability depends on the probability distribution of the error term.

Two distributions of the error term are commonly assumed, both having a mean of 0. The first one assumes that the error term is normally distributed with Var (ε) =1. This yields a binary probit regression model, where equation (6) above becomes:

$$\Pr(y = 1|x) = \int_{-\infty}^{\alpha+\beta x} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{t^2}{2}\right) dt \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (10)$$

Alternatively, when the error term is assumes to be logistically distributed, a logistic regression model is assumed. This study assumed the probit model because the data were standardised during principal component analysis and so the error term were assumed to be normally distributed.

For both probit and logit models, the probability of an event occurring is the cumulative density function (cdf) of the random disturbance term evaluated given values of the independent variables;

$$\Pr(y = 1|x) = F(x\beta) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (11)$$

Where F is the normal cdf[1] Φ for the probit model.

The chosen model expressed the observed outcome in terms of a latent variable given by:

$$y_i^* = \beta_0 + \beta_j x_{ij} + e_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (12\ a)$$

$$y = \begin{cases} 1\ if\ y_i^* > 0 \\ 0\ if\ y_i^* \leq 0 \end{cases} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (12b)$$

wherey_i^* is the latent variable for drought resilience, for household *i*; β_j represents parameter *j* to be estimated; x_{ij} represents explanatory variable *j* for household *i*, ande_i = $N(0, \delta^2)$ is the normally and identically distributed random error term. The probit regression model that was used to identify determinants of resilience was:

[1]This means the cumulative density function of the normal distribution

$$Resilience = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 HHSize + \beta_4 Educ + \beta_5 Land + \beta_6 No.of\ Chickens + \beta_7 No.of\ Goats + \beta_8 No.of\ Bicycles + \beta_9 No.of\ family\ members\ outside\ household + \beta_{10} Freq.of\ dryspells\ over\ 5\ yrs + \beta_{11} Participation\ in\ VSL \ldots \quad (13)$$

A description of variables used in the model is given in table 3.3 below:

Table 3.3 Description of variables used in the probit model

Variable	**Description**
Resilience	$Resilience = 1$ if the household has a resilient score of greater than 0 and $resilience = 0$ otherwise
Gender	1=Female, 0= Otherwise
Age	Number of years
HH_Size	Size of the farm family (number of people)
Educ.	Number of years spent in (primary) school
Land	Amount of land (acres) owned by the farming household
No. of chickens	Number of chickens owned by a farming household
No. of Goats	Number of goats owned by a farming household
No. of Bicycles	Number of bicycles owned by the farming household
No. of family members outside household	Number of immediate family members living outside the household
Freq. of dry spells over 5 years	Number of times a farming household is affected by dry spells over a five year period
Participation in VSL	1= Household participates in VSL, 0 =Otherwise

3.6.3 Model for determining the effect of drought resilience on farm household welfare

In order to test the second hypothesis, a stochastic production function for maize was estimated. The amount of maize (Kg) produced (in 2013/14 season) was used as a proxy for farmer wellbeing. The stochastic frontier approach is a parametric technique that uses the standard production methodology. The work on stochastic frontier was pioneered by Farrell (1957), which was followed by the work of Aigner, *et al.* (1977), Battese (1991), among other authors. According to Aigner *et al.* (1977), other methods that were used to estimate the production frontier had some limitations which the stochastic frontier approach addressed. The estimation of a stochastic frontier begins by assuming that the maximum possible output as a function of inputs given denoted by:

$$Y = (\boldsymbol{x\beta}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

where:$Y$is the estimated output; $\boldsymbol{x}$represents a vector of inputs; and$\boldsymbol{\beta}$represents a vector of parameters to be estimated. In the early work of estimating production functions, most researches used Ordinary Least Squares (OLS) regression techniques to estimate the production functions, which was given as:

$$Y_i = (\boldsymbol{x\beta}) + v_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

where v_i represents the error term.This work assumed that all firms were efficient in their production processes and that all deviations from the efficient output were due to some noise caused by some missing variables and errors in measurement. Other researchers, including Farrell (1957) used the deterministic approach to estimate production functions. This approach fits a deterministic frontier over the data and assumes that there is no noise in the data and that all deviations are due to inefficiency in production. This approach was presented as:

$$Y_i = (\boldsymbol{x\beta}) - u_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(16)$$

where u_i represents the inefficiency component.The stochastic frontier approach recognises that the "the production process is subject to two economically distinguishable random disturbances with different characteristics", (Aigner, *et al.,* 1977:24). This approach tries to create a balance by adding the two error terms, one for the noise and another for technical inefficiency to make it possible for standard hypothesis tests. The trans-log functional form of the stochastic frontier is given as:

$$\ln Y_i = \beta_0 + \sum_{i=1}^{N} \beta_n \, lnx_n + 1/2 \sum_{n=1}^{N} \sum_{m=1}^{M} \beta_{mn} lnx_n lnx_m + v_i - u_i \ldots\ldots\ldots\ldots\ldots..\ldots..(17)$$

The trans-log stochastic frontier approach was preferred over the standard Cobb-Douglas because of its ability to exhibit non-constant marginal productivity. This implies that the trans-log function can exhibit increasing, decreasing, constant or negative marginal products simultaneously. The second reason for the preference of the trans-log over the Cobb-Douglas function is that more than two variables were used in the model so the assumption of constant elasticity of substitution required by the Cobb-Douglas model would be highly unattainable. In addition the assumptions of homogeneity and separability in the conventional Cobb-Douglass imposes more restrictions on the model, which would bias the estimates. The trans-log form of the model that was estimated was:

$$Y_i = \beta_0 + \beta_1 Land + \beta_2 Labour + \beta_3 Capita + \beta_4 Seed + \beta_5 DRI + v_i - u_i \ldots\ldots(18)$$

where; Y_i was the maize output (Kg) for household i; $Land$ was the actual amount of land (acres) used by household i in producing maize; $Labour$ was the amount of labour (person hours) used by household i in producing maize; $Capital$ was the amount of Kwacha (MK) used in other farm activities apart from purchasing inputs for maize production; $Seed$ was the actual amount of maize seed (Kg) planted by household i; DRI represented the drought resilience index for household i ;β_i represents a vector of parameters to be estimated for each household i; $v_i \sim N(0, \delta_v^2)$ is a two sided error term representing stochastic noise for each household i and $u_i \geq 0$ is a one sided error term representing technical inefficiency for each household i.

All the factors of production were expected to be positively correlated with production but there was no apriori expectation for the sign of the drought resilience index (DRI).The DRI was included in the model to measure the effect of drought resilience on household welfare. A positive sign on the parameter for the DRI would mean that households that are resilient are more likely to have improved welfare as compared to those households that are less resilient, *ceteris paribus*.

The independent variables were tested for the possible existence of multi-collinearity. Multi-collinearity occurs when there are high levels of linear correlations among independent variables in the model. The presence of multi-collinearity leads to incorrect coefficient estimates. Where intolerable levels of multi-collinearity were established in the data, a correction was done by dropping one of the variables that were highly collinear. Robust standard errors were used to correct for the possible existence of heteroskedasticity, which is the exhibit of non-constant variance in the data. Presence of heteroskedasticity leads to high standard errors and hence the coefficient estimates are inefficient under heteroskedasticity.

3.7 Socioeconomic, demographic, community and farm characteristics of respondents

Table 3.4 below shows descriptive statistics for variables that were used in the analysis. The table provides summary statistics for variables that were used in testing the two hypotheses that address objectives of the study.

Table 3.4 Descriptive statistics for variables used in the analyses

Variable	Units	Mean	Std.Dev
Age of HH Head	Years	45.9836	16.2730
Years of primary Education	Years	3.1827	3.1264
House hold size	Number of people	5.5527	2.1272
Relatives outside household	Number of people	2.6724	2.3215
Land Holding size	Acres[2]	2.5942	1.5256
Labour	Person hours	99.1429	63.8950
Capital (Investment)	Malawi Kwacha	5,056.0330	12125.24
Seed	Kilograms	9.4660	6.2375
Output	Kilograms	544.9719	453.4892
Gender	1 = Female 0 = Otherwise	0.2622	0.4404
Participation in VSL activities	1 = participated 0 = Otherwise	0.2740	0.4465
Possession of radios	Number of radios	1.0769	0.2678
Possession of bicycles	Number of bicycles	1.0833	0.3239
Possession of goats	Number of goats	3.8571	3.6706
Possession of chickens	Number of chickens	5.2326	5.1056
Frequency of dry spells	Reported cases over a five year period	2.6885	0.8715

[2] Land was measured in acres because the mean landholding size was slightly above one hectare which could lead to negative values if natural logs were taken during data transformations

3.7.1 Age of household head

Age of the household head is very important because it affects the decisions that a household makes regarding production and adoption of farming methods that may directly or indirectly affect the resilience of concerned farming households to dry spells. In their study, Tesso *et al.* (2012) and Andersen and Cardona (2013) determined that age of the household head was one of the factors that explained resilience or vulnerability to adverse shocks. Differences in resilience among households headed by people in different age categories may help the Government and other stakeholders to target the people that are in need of external support to improve on their resilience. The study makes no apriori expectation on the sign for age of the household head because of the ambiguity that arises by considering that households headed by young people are more likely to be small and hence require less resources to sustain but may be less experienced to deal with shocks while households headed by older members could have experience in dealing with many complications that may face a household over time of its existence.

3.7.2 Gender of household head

Gender of the household head may be very important in affecting resilience because it affects opportunities to possession of valuable resources in most communities. In a study by Andersen and Cardona (2013), gender of the household head was found to be insignificant but their results showed that households headed by males were more likely to be less vulnerable as compared to households headed by females. In this study, it was hypothised that male headed households would be much more resilient compared to households headed by females. This is because in the context of Malawi, households headed by men are more likely to have access to productive resources such as land and credit as compared to female headed households, except in matrilineal systems.

3.7.3 Number of years spent in school by household head

The level of education of the household head is an important attribute that affects decision making within the household. Households that are headed by members with better education are more likely to have access to better opportunities especially those that relate to earning off-farm incomes which can be an important aspect in enhancing resilience of the household. In this study the number of years spent in primary education were considered because it was the level which most of the household heads attended. Only less than 10 per cent of the respondents in the study acquired education higher than primary level, so it was considered important just to use primary education. The variable number of years spent in school was used to measure the ability of farming households to adopt new farming technologies that could enhance resilience if adopted. In their study, Keil *et al.* (2006) and Tesso *et al.* (2012) used education as one of the variables that affected resilience of a farming household. In this study, it was hypothised that education would have a positive correlation to resilience of a farming household.

3.7.4 Size of the farm family

Size of a farm family is a very important characteristic because it can affect the household labour capacity. A household that has more elder members that are working on the farm is more likely to have less problems in having farm labour than a smaller household. This, however, comes with a cost of requiring more food for the members of a large household as compared to a smaller household. Tesso *et al.* (2012) and Andersen and Cardona (2013) identified the number of persons in a household as one of the factors that determined resilience in their study which was conducted in Bolivia. This study makes no apriori expectations about the direction of this variable because of the ambiguity that it presents regarding costs and benefits presented earlier. The average size of the farm family of 5.6 persons per household in the study area is slightly above the national average of about 4.5 persons per household as of the 2008 census.

3.7.5 Frequency of dry spells

Frequency of dry spells is an important characteristic that may affect resilience of affected families. It is expected that households whose farms are more frequently affected by dry spells can either be resilient or not depending on how the concerned households responds to the occurrence of dry spells. Households that are affected and have more options to respond to the dry spells can be expected to be resilient while those that do not have options to respond are more likely to be less resilient to adverse effects of dry spells. It was thus, expected that frequency of dry spells could carry a negative sign in the results. Tesso *et al.* (2012) used experience of a natural shock (number/year) as one of the variables in their study on resilience to climate change induced shocks in Ethiopia.

3.7.6 Number immediate relatives living outside the household

Presence of immediate family members who live outside the household is an important characteristic of farm families because if these households get any shocks in the short term that disturb their farm production, the relatives can send remittances that can help to smooth consumption in the affected households. Andersen and Cardona (2013) found that remittances or transfers from other households were important in explaining resilience among households affected by shocks in Bolivia. In the case of Salima and other parts of the country, some households receive remittances from family members who live and work in cities or in other countries, especially in the Republic of South Africa. The study hypothised a positive correlation between remittances and resilience. The family members considered in the study are those that used to live in the family before the moved to live elsewhere. This variable was used as a proxy for remittances in this study.

3.7.7 Liquid Assets Possessed by a household

Possession of assets that can be easily converted into cash could help a household to absorb adverse effects of dry spells and drought. After analysing descriptive statistics for most of the assets that were measured, only bicycles, chickens and goats were considered to be liquid and possessed by many of the studied households. It is important to notice that not all respondents possessed these assets and descriptive statistics were calculated only for those households that possessed the assets. Tesso *et al.* (2012) used liquid assets as one of the factors in their study on analysis of vulnerability and resilience to climate change induced shocks in Ethiopia. The study expected possession of liquid assets to be positively correlated to household resilience to dry spells.

3.7.8 Variables relating to estimation of production functions

Many studies that have estimated production functions have used variables such as land, labour, capital, seed and output as key variables that farmers use in agricultural production. These variables were adopted from several studies (such as Battese, 1991, Solis *et al.*, 2007 and Magreta, 2011). All studies that have estimated production functions use these variables and this study adopted the same. All independent variables are expected to be positively correlated to farm output, which is usually used as a dependent variable.

3.8 Community Characteristics that affect household resilience

Resilience of a household to dry spells and droughts is a function of many other factors. One of the important sets of these factors is community characteristics. This set of factors was considered to be important because a household is an important element of the community and so we do not expect farming households to live in isolation. The culture of most Malawian societies requires that people should be together in times of misfortune. Since dry spells do not affect only one household at a time, the present study sought to assess how households have teamed up at community level to respond to adverse effects brought by dry spells. The study considered participation in village savings and loan groups, which is now discussed.

3.8.1 Participation in village savings and loan (VSL) groups

Participation in village savings and loans considered important because it is a way in which rural people invest in each other, as micro-insurance, to team up against adverse occurrences in their communities. Since the effects of dry spells and drought are not evenly spread among all members of the community, some members who experience less loss are more likely to assist those that have suffered more loss from adverse environmental occurrences. The study expected a positive correlation between participation in microfinance activities and resilience of a farming household to adverse effects of dry spells.

3.9 Limitations of the study

This study examined most important issues that affect the livelihood of farming communities in Chipoka EPA. With all the efforts put in this work, it is important to recognise that the work had some gaps. We now highlight some of the key limitations to the study.

The major limitation of the study was that it was conducted in only one Extension Planning Area (EPA) with almost the same agro-ecological, geographical and climatic patterns. The implication for this was that the results may not be extrapolated to the whole district. This was the case because of the budget constraint.

The other limitation of this study was that it only focused on household resilience but resilience is a function of different socio-systems. The community in which a household is located plays a crucial role in influencing resilience of the concerned household. The scope of the study was, therefore, limited because of time and the budget constraints.

3.10 Summary

This chapter presented methods that were used in the study. A detailed description of the conceptual framework, the study area, sampling methods and analytical techniques for achieving the two objectives have also been presented. The chapter also provided descriptive statistics for household socioeconomic, demographic, community and farm characteristics that were hypothised to affect resilience of a household to dry spells and drought. These variables were used in conducting quantitative analysis that helped to achieve objectives for the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents results of empirical analyses conducted on the data. It starts by presenting a matrix of correlations among variables and some tests that warranted application of the principal component analysis.

4.2 Correlation matrix for variables

One of the key assumptions that warrant the use of principal components analysis is that there must be larger correlations among related variables. The correlation matrix was run to assess whether there were any correlations among the variables used in the analysis. Table 4.1 below shows that the first two variables had a higher correlation of 0.6475 and a higher correlation of 0.505 was also observed between the last two variables. This was expected because variables that correlated highly were measuring the same construct. The first two variables were measuring the amount of food produced in good and bad years, respectively, meaning that the two indicators were production indicators. The last two variables were measuring the number of months a household consumed home produced food in good and bad years, respectively. It is important to notice that variables that were measuring different constructs correlated lowly and this result was also not surprising as it was expected. Variable that had correlations of less than 0.5 were considered lowly correlated while those above the threshold were considered to have adequate correlations to warrant the analysis. Table 4.1 below presents a matrix of correlation coefficients among variables that were used in the analysis:

Table 4.1 Correlation matrix for variables for dimension reduction

	Prod. good year	**Prod. bad year**	**Months good year**	**Months bad year**
Prod. good year	1			
Prod. bad year	0.6475	1		
Month good year	0.115	0.121	1	
Months bad year	0.1016	0.0683	0.505	1

Since the correlations provided by the correlations matrix were not assessed as to whether they were suitable or not, the Bartlett's test of sphericity was conducted on the data. The objective of the test was to test the hypothesis that variables that were used in principal component analysis were not inter-correlated and that non-zero correlations in the sample matrix are due to sampling error (Friel, undated). Failing to reject the null hypothesis would mean that the data were not suitable for dimension reduction, whereas rejecting the null hypothesis would mean that there were suitable correlations between variables allowing for variables to be reduced into a smaller number of components. The Bartlett's test of sphericity calculates the determinant of the sums and cross products from which the inter-correlation matrix is derived. The determinant of the inter-correlation matrix is then converted into a Chi-square statistic and then tested for significance. The results of the test are shown in table 4.2 below;

Table 4.2 Results of the Bartlett's test of sphericity

Determinant of the correlation matrix	0.424
Bartlett test of sphericity	
Chi-square	363.871
Degrees of freedom	6
p-value	0.000
H0: variables are not inter-correlated	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	
KMO	0.516

Table 4.2 above shows results of Bartlett's test of sphericity. Results show that a Chi-square value of 363.871 was obtained with 6 degrees of freedom. The p-value of 0.000 was reported. The statistical decision that was made based on these results was that the inter-correlation matrix did not come from a population in which the inter-correlation matrix is an identity matrix. This means that we reject the null hypothesis and conclude that the variables used in the study were inter-correlated and that the correlations did not result from a sampling error. This means that there were suitable correlations to warrant the application of the principal components analysis on the data.

Another important assumption for use of principal components analysis on the data is that the sample size must be large enough. This assumption is measured using the Kaiser-Meyer- Olkin measure of sampling adequacy. The results displayed above also shows results of the Kaiser-Meyer- Olkin (KMO) measure of sampling adequacy. This criteria required that the KMO value should be at least 0.5 to allow principal component analysis to be applied on the data. The KMO value of 0.516 falls slightly above the threshold value of 0.5 thereby allowing for PCA to be applied on the data. The smaller value of the KMO, however implied that the degree of common variance among the variables is not very big. This means that if PCA is applied on the data, the components will account for a fair amount of variance but not substantial (Friel, undated). Since the data met the minimum requirements for both the Bartlett's test of sphericity and the KMO, the data were considered suitable for dimension reduction using the principal component analysis. Table 4.3below shows the results of the principal components analysis;

Table 4.3 Results of the un-rotated principal components

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.79196	0.4303	0.4480	0.4480
Comp2	1.3617	0.8651	0.3404	0.7884
Comp3	0.496634	0.1469	0.1242	0.9126
Comp4	0.349705	.	0.0874	1.0000
N=427 Components = 4 Trace = 4 Rho = 1.0000				

The table 4.3 above shows results of the principal components analysis. In the initial solution, each of the variables was standardized to have a mean of 0 and a variance of 1. For four variables used, the total variance that must be explained was 4. Since a variable can account for 1 unit of the variance, a useful variable must account for more than 1 unit of variance or it must have an [3]eigen value of greater than 1.The first principal component explained 44.8 per cent of the total variance while the second explained about 34 per cent of the total variance. From this it could be observed that the first two components have eigen values greater than unity which explain most of the variance and so can be considered for selection for further analysis. From the results it would be important to learn that the trace is the sum of entries in the main diagonal of the correlation matrix. The Rho value of 1 meant that all the variance was

[3] The number λ is an Eigen value of matrix A if and only if $A - \lambda I$ is singular i.e. Det $(A - \lambda I)$ =0.

explained by the variables that were used. In order to choose the component for data reduction, the components were compared with apriori expectations. In order to select which variables to use, it was important to get component loadings, which are given as eigen vectors. Table 5.4 below shows results of the component loadings (Eigen vectors):

Table 4.4 Eigen vectors from the principal components analysis

Variable	Comp.1	Comp.2	Comp.3	Comp.4	Unexplained
Production in good year	0.5807	-0.4000	0.1159	-0.6995	0
Production in bad year	0.5734	-0.4163	-0.0738	0.7018	0
Consumption months in good year	0.4230	0.5614	-0.7059	-0.0868	0
Consumption months in bad year	0.3937	0.5929	0.6948	0.1030	0

The table 4.4 above shows results of the [4]eigen vectors from the correlation matrix. The values under intersection between each variable and component represent component loadings. These are correlations between the variables and the components. Looking at the signs of the component loadings and comparing with apriori expectations, it can be noted that only the first component has expected apriori expectation. This means that the first component which explains 44.8 per cent of the total variance can be used to construct the drought resilience index. This means that component loadings for the first component were used as weights in generating the resilience index which was given by:

[4]Let A be a square matrix on order n, if there exist a non-zero column vector x and a scalar λ such that $Ax = \lambda x$ then λ is an eigen value of matrix A and x is the corresponding Eigen vector for the Eigen value

$$Drought\ Resilience\ index$$

$$= 0.5807 * production\ in\ good\ year + 0.5734 * production\ in\ bad\ year$$
$$+ 0.4230 * months\ consuming\ home\ maize\ in\ bad\ year + 0.3937$$
$$* months\ consuming\ home\ produced\ maize\ in\ bad\ year \ldots\ldots\ldots\ldots. (19)$$

The formula given in equation (16) above was applied on the data to generate the drought resilience index for each of the household which are presented in table 4.5 below. Results indicate that an average household in the study area has a mean resilience index of -0.0857. Since the scores were normalised, implying that they had a mean value of 0 and a standard deviation of 1, a household was considered to be resilient if it had a resilient score of equal to or greater 0, which was used as a cut-off point to classify a household as either resilient or otherwise. The observed results suggest that 163 households, representing about 38 percent were resilient to dry spells while the other 264 households, representing 62 percent of total households in the area are not resilient to adverse effects of dry spells and drought. A larger value of standard deviation on the aggregated DRI compared to the mean score indicate that there were larger variabilities in calculated resilience scores among farming households in the study area. The table 5.5 below provides summary statistics for the drought resilience index:

Table 4.5 Summary statistics for the drought resilience index

Variable	N	Mean	Std. Dev.	Min	Max
DRI	427	-0.0857	0 .8809	-1.7965	5.1139
DRI >= 0	163	0.7916	0.7499	0.0068	5.1139
DRI< 0	264	-0.6273	0.3732	-1.7965	-0.0129

Figure 4.1 below shows the kernel density function of the drought resilient indices that were estimated to provide a visual impression of the DRI.

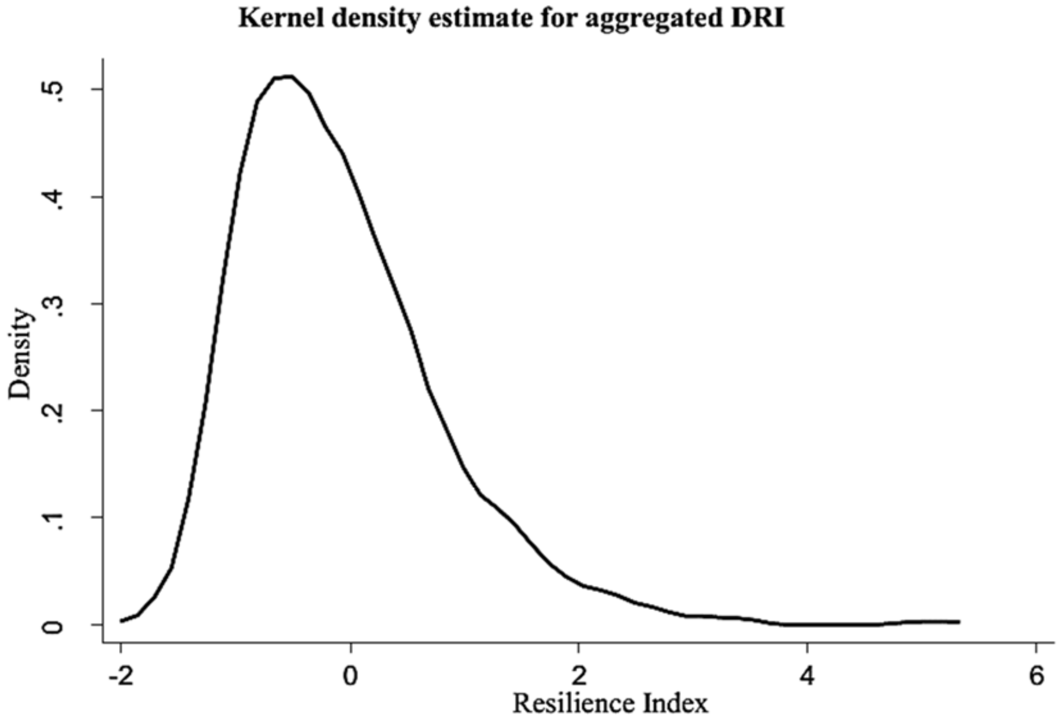

Figure 4.1 Kernel Density estimate of the drought resilience index

The figure 4.1above shows that resilience indices were skewed to the left, meaning that the most households in the study area were less resilient and hence vulnerable to adverse effects resulting from occurrence of dry spells. This confirms summary statistics that were presented in table 4.5 above. Since the study was conducted in areas of two traditional authorities it was important to compare summary statistics for the resilience indices by traditional authority. Table 4.6 below shows summary statistics for the drought resilience index compared by traditional authority.

Table 4.6 Drought resilience indices by Traditional Authority

Group	N	Mean	Std. Err.	Std. Dev.
Ndindi	184	-0.2781	0.0565	0.7657
Kambalame	243	0.0601	0.0599	0.9346
Combined	427	-0.0857	0.0426	0.8809
Diff		-0.3382	0.0846	

diff = mean(Ndindi) – mean(Kambalame) t = -3.9968

Ho: diff = 0 degrees of freedom = 425

Ha: diff< 0 Ha: diff != 0 Ha: diff> 0

Pr(T < t) = 0.0000 Pr(|T| > |t|) = 0.0001 Pr(T > t) = 1.0000

The table 4.6 above highlights that the average farm household in the area of Traditional Authority Kambalame is relatively more resilient as compared to an average household in Traditional Authority Ndindi. This is evidenced by a t value of -3.9968 and a P-value of 0.0001 for a two sided test. These findings confirm statements that were made by the Agricultural Extension Development Coordinator (AEDC) for the area who said that TA Kambalame has some areas that are less affected by dry spells than most areas in TA Ndindi that are within the same study area. This could be explained by the observation that a large area of traditional authority Kambalame is wetter (is close to the lake and has a larger river flowing through it)and has an irrigation scheme than that of traditional authority Ndindi implying that most dry lands in the area of Ndindi receive less precipitation. This finding is confirmed by results in the table 4.7 below which provides a summary of results obtained from a t-test for maize production figures for the areas;

Table 4.7 Mean production levels in areas of Ndindi and Kambalame

Group	N	Mean	Std. Err.	Std. Dev.
Ndindi	184	434.7011	29.0662	394.274
Kambalame	243	628.4691	30.6459	477.7216
Combined	427	544.9719	21.9459	453.4892
Diff		-193.768	43.3619	
diff = mean(Ndindi) - mean(Kambalame)			t = -4.4686	
Ho: diff = 0			degrees of freedom = 425	
Ha: diff< 0		Ha: diff != 0	Ha: diff> 0	
Pr(T < t) = 0.0000		Pr(|T| > |t|) = 0.0000	Pr(T > t) = 1.0000	

Results in Table 4.7 above suggest that farmers from the area of traditional authority Ndindi harvest relatively less output as compared to their counterparts from Kambalame. This is evidenced by results from a two sided test provided in the table above, where a t value of -4.4686 was obtained with a P-value of 0.0000 hence rejecting the hypothesis that mean production levels for the two groups are equal. This may partly explain the observed differences in the mean resilience scores from the two areas.

4.3 Determinants of household resilience to dry spells and drought

After calculating the resilience indices for each farming household it was important to identity factors that affect resilience of concerned households. This section presents findings on factors that were hypothised to affect resilience to dry spells among affected households in the study area. Some of the household socioeconomic, demographic, community and farm characteristics that were discussed in chapter three were used as independent variables to explain resilience in the probit regression model. Before presenting the results, the variables were tested for possible multi-collinearity. Table 4.8 below shows results of the multi-collinearity diagnostics for the explanatory variables.

Table 4.8 Variables showing multi-collinearity problem

Variable	VIF	Tolerance
Gender	1.26	0.7966
Age	38.62	0.0259
Age squared	38.19	0.0262
Size of HH	1.29	0.7740
Years in school	1.26	0.7930
Land holding	1.23	0.8136
Chickens	1.31	0.7605
Goats	1.26	0.7918
Bicycles	1.24	0.8093
Relatives in cities	1.08	0.9275
Frequency of dry spell over 5 years	1.04	0.9596
Participation in micro-finance	1.10	0.9073
Mean VIF	**7.41**	

The table 4.8 shows existence of the multi-collinearity problem among independent variables. The variables age and age squared showed the variance inflation factors of greater than 10 indicating presence of high multi-collinearity among the explanatory variables. Estimating the model with multi-collinearity problem would result in inaccurate coefficient estimates and hence lead to incorrect decision making from the analysis. In order to correct for the problem, we dropped the variable age squared from the list of explanatory variables and run another test. Table 4.9 that follows shows results of the multi-collinearity diagnosis.

Table 4.9 Collinearity diagnosis indicating absence of multi-collinearity

Variable	VIF	Tolerance
Gender	1.25	0.8008
Age	1.18	0.8474
Size of HH	1.10	0.9092
Years in school	1.25	0.7968
Land holding	1.23	0.8151
Chickens	1.31	0.7610
Goats	1.26	0.7923
Bicycles	1.24	0.8096
Relatives in cities	1.07	0.9353
Frequency of dry spells over 5 years	1.04	0.9627
Participation in micro-finance	1.10	0.9086
Mean VIF	**1.18**	

The table above shows the absence of intolerable levels of the problem of multi-collinearity among the independent variables. This is shown by VIF values of less than 10 for each of the variables and a mean VIF value of 1.18 which is far much less than 10. This means that the variables have been cleared from the problem of multi-collinearity. The variables were then used in identifying factors that affect resilience.

4.3.1 Results of the probit analysis

Table 4.10 shows results of the probit regression model that were obtained to determine factors that were considered to affect resilience among farming households in the study area. Since variables age and age squared were found to be collinear, the age squared variable was dropped from the model. Robust standard errors were used to take care of the possible hereteroskedasticity problem in the data. Results of the analysis are now presented.

Table 4.10 Results of probit regression model and marginal effects

	Coefficient	**P-value**	**Marginal Effects**	**P-value**
Gender of household head	-0.1601 (0.1725)	0.349	-0.0596 (0.0631)	0.341
Age of household head (years)	0.1595** (0.0687)	0.031	0.06020** (0.0258)	0.031
Size of household (number of people)	0.3426*** (0.0725)	0.000	0.1293*** (0.0273)	0.000
Years spent in school by household head	0.1072 (0.749)	0.144	0.0404 (0.0283)	0.144
Land holding size (Acres)	0.3923*** (0.0890)	0.000	0.1481*** (0.0339)	0.000
Number of Chickens	0.0704 (0.0809)	0.378	0.0266 (0.0306)	0.378
Number of Goats	0.0936 (0.0903)	0.264	0.0353 (0.0341)	0.265
Number of Bicycles	0.0153 (0.0740)	0.839	0.0056 (0.0279)	0.839
Immediate family members outside the household	0.0662* (0.0338)	0.060	0.0249* (0.0127)	0.060
Frequency of dry spells over 5 year period	-0.0366 (0.0769)	0.641	-0.0138 (0.029)	0.642
Participation in village savings and loans	0.2393 (0.1554)	0.119	0.0916 (0.0601)	0.123
Constant	-0.3302 (0.2258)	0.155		

N = 427 Wald chi2(11) = 79.8 Prob. > chi2 = 0.000 Log pseudo likelihood = -236.25264
Pseudo R2 = 0.1679
y = Pr(Resilience) = 0.3696
***1% level of significance, **5% level of significance and *10% level of significance
Values in Parentheses are robust standard errors

The table 4.10 shows results of the probit regression model run on the data. Results indicate all variables had met apriori expectations on the direction of the variables. Results also suggest that age of the household head, size of the household, amount of land held (acres) and number of immediate family members living outside the household affected resilience of farming households to dry spells and drought. Literature has it that that results of probit model are difficult to interpret , for example, Cameron and Trivedi (2005) have argued that for binary outcome models, interest comes in determining the marginal effect of change in a regressor on the conditional probability of the expected outcome (thus, that y = 1. For this reason, the discussion of results was aimed at interpreting the marginal effects while the probit results were useful in showing the direction of change in the concerned variables. The variables are now discussed in detail.

4.3.2 Age of the household head

Age of the household head affects resilience of a farming household to dry spells and drought. Results suggested that households with older household heads tended to be more resilient when compared to households that were headed by younger household heads. This result means that up to a certain point in the model, for a unit increase in the age of the household head, the log likelihood of a farming household being resilient to dry spells increases by 0.1595.

The value of 0.0602 on the marginal effect for the age variable means that up to a certain point, for any one year increase in the age of the household head, the probability of the household becoming resilient to dry spells and drought increases by 0.0602, holding all other factors at their mean values. This could be because older household heads may have experience in adopting other ways of survival much more quickly as compared to their young counterparts.

Another explanation for the result could be that older members have well established social networks in the community such that it could be relatively easy for them to ask for help from a wider network of friends and relatives in times of need as compared to their younger counter parts. This was consistent with Andersen and Cardona (2013) who found that age of the household head had a positive and significant effect in determining resilience to adverse shocks in Bolivia. The findings, however, do not agree with Keil *et al.* (2006) who found that age had a positive but insignificant effect on resilience to adverse effects of dry spells. The difference with the findings of Keil *et al.* (2006) could be due to the differences in the methods used and contexts in which the studies were conducted.

Since the variable age squared was dropped because of the multi-collinearity problem it brought when included in the model, there was interest to check its direction when it was included in the model. Results indicated that age squared carried a negative and significant sign at 10 per cent level of significance implying that as the age of the household head progressively increased, the ability of the farming household to be resilient declined.

The possible explanation for this finding could be that as a person becomes older, his/her ability to work is reduced by old age and this has a negative bearing on access to different income generating activities by the household.

4.3.3 Size of the household

Size of the farm household significantly affects resilience of a household to dry spells and drought. The value of 0.3426 on the coefficient for size of the household means that up to a certain point, for any increase in the size of the household by one member, the log likelihood of a household's resilience is expected to increase by 0.3426. Within that range any increase in size of the farming household increases the log likelihood of a household being resilient to dry spells. The results of the marginal effect on the variable size of the household suggest that up to a certain point, for a one person increase in the size of the household, the probability of the household becoming resilient to adverse effects of dry spells and drought increases by 0.1293, holding all other factors that affect resilience at their means. The result is consistent with Keil *et al.* (2006) who determined that household size had a positive and a significant effect on household resilience. This result could be explained by the argument that relatively larger households are more likely to have enough labour capacity for working in the farms and hence, holding all other factors constant, would produce more output.

The other argument for this observation could be that large households are more likely to have diversified sources of incomes, and hence be more resilient as compared to smaller households. This, however, does not come without contradiction because of the challenges that are associated with larger households. The result is, thus, confusing in the context of Malawi.

4.3.4 Land holding size

Land holding size was also found to significantly affect the resilience of a farming household to dry spells and drought. Results suggest that for any increase in the amount of land owned by the faming household by one acre, the log likelihood of a household's resilience increases by 0.3923. This means that, holding all other factors constant, households with more land are expected to be more resilient to dry spells and drought.

The marginal effect coefficient of 0.1481 means that increasing the amount of land used by a farming household by one acre increases the probability that a household becomes resilient by about 0.15, holding all other factors at their mean levels. This result may be explained by the fact that households that have more land and use it for producing food may harvest more food compared to a household that has less land.

The findings are consistent with Scott *et al.* (2014) who determined that an increase in own cultivated farmland was associated with being outside the poverty wave in Ethiopia. The result could be explained by the argument that households that own large pieces of land are encouraged to invest on their land by adopting productivity enhancing technologies as compared to households that have less land. For example, households that have less land are less likely to farrow their land because they just have less and need to use it every growing season. The implication is that the land gets overused and so it becomes less productive. It is also difficult to invest on borrowed land because of the uncertainty that the landlord/ landlady may want the land back when massive investments have already been made on it. An example of such massive investments could be investment in irrigation equipment which is expensive but difficult to dispose.

4.3.5 Number of immediate family members living outside the household

Results of the analysis provide enough evidence to suggest that a household that has immediate family members living outside the household tend to be more resilient to dry spells compared to households that do not have relatives outside their households. The findings indicate that for any increase in the number of immediate family members living outside the household by one person, the log likelihood of a household's resilience increases by 0.0662. It is important to bear in mind that this argument is valid if and only if the relatives that are living outside the household send some money to the villages in the form of remittances.

The marginal effect coefficient of 0.0249 implies that increasing the number of immediate family members living outside the household results in a corresponding increase in the probability of a household becoming resilient by 0.0249. This result suggests that households that have more relatives living outside the household are more likely to benefit from remittances and hence become resilient. This finding is consistent with Andersen and Cardona (2013) who determined that households that received remittances (both local and international) in Bolivia were thirteen times likely to belong to a resilient group than those that did not. These findings are logical because remittances provide an opportunity for households that face shocks to cushion the adverse effects which may have serious implications on household purchase and consumption of food in such times.

Despite not being significant, it can be noted in the table above that results suggest that male headed households are more likely to be more resilient as compared to female headed homes. It can also be observed that participation in village savings and loan initiatives was positively associated with resilience to dry spells and drought. Results also suggest that possession of assets that can be easily turned into cash and number of years spent in primary school are positively associated with household resilience to dry spells while high frequency of dry spells on the farm negatively affects resilience.

4.4 Effect of the resilience on farm household welfare

This segment establishes the effect of the resilience on farm household welfare. A stochastic production frontier was estimated with farm level output as a dependent variable which was also used as a proxy for farm household welfare. The explanatory variables used were amount of land (acres) allocated to maize production, amount of seed (kg) planted, amount of money (Kwacha) invested in maize production, amount of labour (person hours) used in maize production and the drought resilient index. Before estimating the stochastic frontier, the independent variables were tested for the possible existence of multi-collinearity. Table 4.11 below shows the results for multi-collinearity diagnosis.

Table 4.11 Collinearity Diagnostics for variables used in estimating the stochastic frontier

Variable	VIF	Tolerance
Land (log)	1.26	0.7957
Seed (log)	1.20	0.8347
Lab (log)	1.41	0.7112
Invest (log)	1.14	0.8768
Res_Index	1.24	0.8068
Mean VIF	**1.25**	

The table 4.12 above indicates the absence of intolerable levels of multi-collinearity among the independent variables in the data. This is shown by VIF values of less than 10 and tolerance levels of greater than 0.1 for all variables used. This clears the variables from the problem of multi-collinearity. The stochastic frontier model was then estimated.

4.4.1 The effect of resilience on farm household welfare

The stochastic frontier model was estimated to determine the effect of the drought resilience index on farm household welfare. Results of the analysis are presented in table 4.12 below;

Table 4.12 The effect of resilience on farm households' welfare

Variable	Coefficient	Z	P-value
Land (log)	0.0752** (0.0358)	2.10	0.036
Seed (log)	0.1786*** (0.0393)	4.55	0.000
Lab (log)	0.0749 (0.0533)	1.41	0.160
Invest (log)	0.045** (0.0077)	5.86	0.000
Resilience Index	0.4475*** (0.0353)	12.69	0.000
Constant	5.7835*** (0.2432)	23.78	0.000

Likelihood-ratio test of sigma_u=0: chibar2(01)= 92.61 Prob.>=chibar2 = 0.000
Values in parentheses are robust standard errors
***1% level of significance and **5% level of significance

The table 4.12 above shows results of the stochastic frontier model. The results suggest that signs conform to their apriori expectations. It can be noted that land, seed, capital investment and the resilience index are significant in explaining farm household welfare. These variables are now discussed;

4.4.2 Land

Findings from the study reveal that land allocated to maize production significantly affects welfare (proxy with farm level output)of a farming household. Results suggest that a one percent increase in the mount of acres allocated to maize production results in an increase in the welfare of a farming household by 0.08 per cent. This means that farmers that use more land are more likely to have better welfare when compared to those that use less land, holding all other factors constant at their mean values. This result is consistent to the work of Solis *et al.* (2007) who found that land significantly affected efficiency of producers in El Salvador and Honduras.

4.4.3 Seed

Results suggest that amount of seed used in maize production significantly affect the welfare of a farming household. The results suggest that up to a certain point, for every one per cent increase in the amount of seed used in maize production, there would be an increase in household welfare by 0.18 per cent, holding all other factors constant at their mean values. This means that within a given range, farmers that use more seed are more likely to have improved welfare (proxy with farm level output) as compared to those that use less seed. This, however, assumes that the crop was well managed and all other inputs were applied, including adequate rainfall. The findings are in not conflict consistent with the work of Magreta (2011) who found that rice seed had a positive but insignificant effect on the efficiency of rice producers. The differences in findings can be attributed to different methodological approaches that were employed in the analyses.

4.4.4 Capital Investment

It was revealed that the amount of money (capital) invested in maize production significantly affect farm household welfare. Results suggest that a one per cent increase in the amount of money (Kwacha) invested in maize production results in an increase in farm household welfare by 0.5 per cent, holding all other factors constant. This could be because farmers that invested more capital in maize production purchased inputs such as fertilizers which helped to increase the level of output. This suggests that farmers that invest more money in maize production are more likely to have better livelihood as compared to those who do not invest or invest less. This may be linked to the fact that farmers that adopt new technologies tend to invest more money on their farms and hence earn more output in return. The finding is also consistent with the work of Magreta (2011) who found a positive and significant effect on technical efficiency of rice producers and investment in fertilisers.

4.4.5 Drought Resilience Index

The main reason for estimating the stochastic frontier was to assess the effect of the drought resilience on farm household welfare (proxy with farm output). Results suggest that drought resilience had a positive and significant effect on farm household welfare. The results suggest that an increase in drought resilient index by one per cent results in an increment in farm household welfare by 0.45 per cent, holding all other factors constant at their mean values. This indicates that farm households that have a positive drought resilience index are more likely to have improved welfare as compared to their counterparts who had a negative drought resilience.

4.5 Summary

This chapter presented results of empirical analyses that were conducted. Results indicate that only 38 percent of farming households in the study area are resilient to dry spells while the other 62 percent are not. A comparison of results by traditional authority revealed that that on average, farming households in the area of Traditional Authority Kambalame were relatively resilient as compared to their counterparts from the area of Traditional Authority Ndindi. Results also suggest that suggest that size of the farm family, age of the household head, size of the family farm and the number of immediate family members working in cities or in other countries affect the resilience of a farming household. The effect of drought resilience on farm household welfare was also established. Results indicate that the drought resilience had a positive and significant effect on farm household welfare. This suggests that farm households that have positive drought resilience indices are more likely to have improved welfare (proxy with maize farm output).

CHAPTER FIVE

CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Key conclusions

Based on the findings from the analyses, the following are the conclusions that have been made from the study:

The study revealed that 38 percent of households were resilient to dry spells and drought while the other 62 percent of farming households were not resilient. With a mean drought resilient index of -0.0857 it was concluded that more farming households were vulnerable to shocks resulting from occurrence of dry spells and drought. This was because most of the households were not able to produce and consume adequate farm output during dry spells.

Since the study area covered two traditional authorities, study findings lead to the conclusion that farm households in the area of traditional authority Ndindi were less resilient to adverse effects of dry spells and drought with the mean resilience score of -0.2781 while on average, households in the area of traditional authority Kambalame were resilient with an average score of 0.0601.

It was also concluded that age of the household head, size of the household, land holding size by farm households and number of immediate family members living outside the household were significant determinants of household resilience to dry spells and drought. The study revealed that older household heads were more resilient than younger household heads, owing to the wider social networks and greater farming experience by older household heads as compared to younger heads.

The results obtained above provide enough evidence to reject the hypothesis that socio-economic, demographic, community and farm characteristics do not affect resilience to droughts and dry spells. This, therefore, means that variables such as age of the household head, size of the farming household, land holding size and number of immediate family members living outside the household affect resilience to dry spells in the study area.

The findings also led to the conclusion that drought resilience had a positive and significant effect on farm household welfare (proxy with farm output). This suggests that farm households that had positive drought resilient indices were more likely to have improved welfare. These results provided sufficient evidence to reject the second null hypothesis that drought resilience does not have any effect on the welfare of farming households.

5.2 Policy Implications

With these key findings in mind, the following are the policy implications;

i. Since land holding size was considered to significantly enhance resilience, it would be beneficial for government and other non-state actors working in the study area to consider introducing productivity enhancing technologies in the area. This is because there was a significant proportion (about 50 percent)of respondents to this study who owned less land than the average land holding of about 2.6 acres per for the average farm family of about 6 people. This implies that increasing farm level productivity would enhance resilience of the concerned farm families. The interventions could be irrigation or promoting use of drought resistance seed varieties.

ii. The other policy implication is that it would be beneficial to encourage farmers to diversify crop production and participate in off-farm livelihood activities so that they diversity incomes from farming. This would help farming households to rely on off-farm sources of incomes in times of shocks. Encouraging farmers to rare livestock would also help in times of need.

iii. For Non-Governmental Organisations (NGOs) working in the area, it could be much more beneficial if the relief items that come in the area were targeted based on age of the household head, size of the family farm, land holding size and number of family members working in cities or in other countries. Targeting relief items based on age could mean that NGOs and other development institutions must aim at reaching households that are headed by child heads and those headed by the elderly. This is because results indicate that households that are in the economically active age group are relatively resilient. Though the variable gender of household head is not significant, results suggest that female headed household are less resilient compared to their male counter-parts so it could also be beneficial to target female headed households with the relief items.

Basing on size of the family it was recommended that interventions to enhance resilience must be targeted to farm families that have very few members and those that have very large sizes. This is because in most cases, households that had few members were mostly composed of older people who could not do much work on their farms. The households that had larger sizes than the average for the area indicated to exhaust their food a few months after harvest and so they were less resilient. Targeting these households could lead to effectiveness in relief services offered by organisations working in the area such as World

Food Programme (WFP), COOPI, and World Vision International (WVI) in Malawi.

Targeting based on size of the farm family could mean that farm families with few or no members that are engaged in economic activities should be prioritised in aid delivery. In families where members are involved in diverse sources of income, the household benefits from the support from the members while in farm families with few or no members involved in economic activities the household head is usually given a huge responsibility of fending for the household even if his/her ability to provide for the family is limited, thus the aid could enhance resilience in these families. Lack of off-farm employment opportunities in the area coupled with reduction in the fish catch from the lake (due to overfishing) has left many people overly on farming and thus making them more vulnerable to adverse effects of dry spells.

Targeting basing on land holding sizes could also be very helpful if those farmers with less land holding per person were prioritised in the irrigation schemes available in the area. If this is done, it would be helpful to intensify production so that productivity is increased on the limited land that farmers possess. This means that households that have the average land holding size but have more members in their household should qualify to participate in irrigation schemes. Implementation of such interventions, however, must be done bearing in mind the long run sustainability and cost implication for the farmers. This could help these farm households to supplement the harvest they get from rain-fed farming on their plots.

Targeting based on number of immediate family members living outside the household should focus on those households that do not have immediate family members outside. This is because even if the people get affected by the same magnitude of a dry spell, those that have relatives are relieved because they get assistance from their relatives in cities or abroad in the form of remittances while those that do not have relations have no reliable source of external support. However, in order to help those that do not have access to remittances, it would be beneficial to encourage diversification away from farming in the area. The help from state and non-state actors should be tailored to increase resilience so that the welfare of concerned farmers is increased.

iv. Since the findings revealed that households in the area of traditional authority Ndindi were less resilient to dry spells as compared to the area of traditional authority Kambalame, it could be much more beneficial if more efforts, that improve resilience, were put into the area of traditional authority Ndindi as compared to the area of Kambalame. This is because if well implemented, the interventions could be much more effective in improving the welfare of farming households in the area of Traditional Authority Ndindi. This, however, does not mean the area of traditional authority Kambalame should be overlooked since there are also people in the area who get affected by dry spells.

5.3 Areas for further study

Acknowledging that the study was only done in one EPA, there is need for other studies to cover wider a geographical area. This would add more value to the work that has already been done by this study.

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APPENDIX

Study Questionnaire

UNIVERSITY OF MALAWI

BUNDA COLLEGE OF AGRICULTURE

Determinants of household resilience to dry spells and drought in Malawi: A case of Salima district

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A Study questionnaire

Introduction

Good morning/afternoon, am …………………. from LUANAR. We are conducting a study to establish key factors that enhance resilience among farming households that are affected by dry spells. The findings from the study will provide a guide to policy formulation that will enhance long term resilience to dry spells. Your household has been randomly selected to participate in this study and you are free to choose not to participate in the study. Your cooperation will be highly appreciated.

Household identification

EPA	
Section	
T/A	**1=Ndindi 2= Kambalame**
Household ID	
Date of interview	
Name of Enumerator	**1= Taonga 2= Edwin 3= Harris 4= Ken 5= Ben 6= Matthews 7= Dan**

A. Socio-economic characteristics

A1.What is the gender of the household head?	0 = male 1 = female
A2.What is the age of household head?	

A3.How many people in the following categories live in this households?

Age group	Male	Female
<10 year old	(1)	(1)
10-14 years old	(2)	(2)

15-50 ears old	(3)	(3)
>50 years old	(4)	(4)

A4.Please give me the name and age of each member in your household

Name	Age	Percent of time spent on farm

A5. Has the household head ever gone to a formal school?	0 = no………….. **SKIP TO A8** 1 = yes
A6. If yes, how many years has the household head spent in school at the highest level?	Level 1= primary, number of years……… Level 2= secondary, number of years…….. Level 3 = tertiary, number of years……….
A7. What is the highest qualification of the household head?	
A8. If none, has the household head attended any informal education?	0 = no……………**SKIP TO A10** 1 = yes
A9. If yes, how many years have been spent in informal education?	
A10.What is the main occupation of the household head?	
A11.What is the secondary occupation of the household head?	
A12.What is the tertiary occupation of the household head?	
A13. Does this household have any relatives living in cities, towns or other countries?	0 = no................ **SKIP TO A19** 1 = yes
A14. If yes, how many relatives stay and work in other places?	
A15. Do these relatives send any form of support to this household?	0 = no, 1 = yes

A16. If yes, has this household received any support from these friends and relatives over the past 12 months?	0 = no, 1 = yes
A17. If yes, when was the last time the household received the support?	
A18. What type of support did the household receive the last time it got the support?	

Type of support	Money Equivalent

A19. Does anyone in this household operate a business of any kind?	0 = no, 1 = yes

B. Types of land and water capitals for winter farming

B1.Does this community have any river (s) close by?	0 = no…………… **SKIP TO B6** 1 = yes
B2. If yes, what is the shortest distance to the nearest river in minutes of walking?	
B3. Is the river seasonal or perennial?	(1) Seasonal (2) Perennial
B4. Does this community have other water sources close by?	0 = no, 1 = yes
B5. If yes, what water source(s) is it/are they?	(1) Well(s) (2) River/stream (3) Lake (4) Borehole (5) Tap (6) Other (specify)
B6. Does this community have a dambo land close by?	0 = no………… **SKIP TO B8** 1 = yes
B7.If yes, what is the distance in meters to the nearest dambo land that your household can access?	
B8. Does your household involve in any winter farming activities?	0 = no………… **SKIP TO B10** 1 = yes

B9. If yes, what crops do you grow?

Crop Name	Sale/consumption	Acres allocated to rain-fed farming	Acres allocated to irrigation
Maize			
Rice			
Soybeans			
Groundnuts			
Cotton			
Tobacco			
Vegetables			
Fruits			
Sugarcane			
Beans			
Other (specify)			

B10. How big is the land (acres) in total that you use as a household?

Rain-fed farm land	Irrigation/dambo land

B11. What type of ownership of land do you have?	1 = customary 2 = rented
B12. In a normal year, how many months does the maize that your household produces last in stock?	
B13. Usually in which month does the household run-out of its maize stock in a normal year?	

C. Farming activities in the last season (2013/14)

C1. What are the quantities of fertilizers that were used in the just ended growing season?	Basal dressing / Top dressing
C2. Did this household use any improved seed varieties in maize production?	0 = no, 1 = yes
C3. Where did your household get the seed that it planted in the just ended planting season?	Recycled from last year……………………….kg Bought from the market……………………….kg Received from friends………………………..kg Bought at full price…………………………..kg Subsidy……………………………………...kg Other(specify)……………………………….kg
C4. How much money did you spend in paying casual labourers?	
C5. How much money did you spend in other investments related to maize production?	
C6. Has this household finished harvesting its maize from the farms?	0 = no 1 = yes………………**SKIP TO C8**
C7. If not, how much land area has been harvested so far?	
C8. How many granaries have been filled so far?	
C9. How many trips of oxcarts have been harvested so far?	
C10. How many 50 kg bags of maize have you harvested so far?	
C11. Other unit of measure (specify) and quantity realised	
C12. How many 50 kg bags of maize do you think you will have in total this year?	

D. Labour usage in maize production

LAND PREPARATION	
D1. How many days did it take to prepare land for maize production?	

D2. How many males from the household were involved? On average how many hours did they work each day?	
D3. How many females from the household were involved? On average, how many hours did they work each day?	
D4.How many males were hired for the task? For how many days did they work?	
D5.How many females were hired for the task? For how many days did they work?	
D6.How much did you pay males workers	
D7.How much did you pay female workers?	
PLANTING	
D8. How many days did it take to plant the maize plot(s)?	
D9. How many males from the household were involved? On average, how long did they work each day?	
D10. How many females from the household were involved? On average, how long did they work each day?	
D11 .How many males were hired for the task? For how many days did they work?	
D12. How many female were hired for the task? For how many days did they work?	
D13. How much did you pay male workers?	
D14. How much did you pay female workers?	
WEEDING	
D15. How many days did it take to weed the maize plots?	
D16. How many males from the household were involved? On average, how long did they work each day?	
D17. How many females from the household were involved? On average, how long did they work each day?	
D18. How many males were hired for the task? For how many days did they work?	

D19. How many females were hired for the task? For how many days did they work?	
D20. How much did you pay male workers	
D21. How much did you pay female workers	
FERTILIZER APPLICATION-BASAL DRESSING	
D22. How many days did it take to apply basal dressing fertilizers?	
D24. How many males from the household were involved? On average, how long did they work each day?	
D25. How many females from the household? On average, how long did they work each per day?	
D26. How many males were hired for the task? On average, how long did each work per day?	
D27. How many male workers were hired for the task? How many days did they work?	
D28. How much did you pay male workers for the task?	
D29. How many females were hired for the task? How many days did they work?	
D30. How much did you pay female workers for the task?	
FERTILIZER APPLICATION-TOP DRESSING	
D31. How many days did it take to apply top dressing fertilizers?	
D32. How many males from the households were involved? On average, how long did they work each day?	
D34. How many females from the household were involved? On average, how long did each work each day?	
D35. How many male workers were hired for the task? How many days did they work?	
D36. How many females from the household were hired for the task? How many days did they work?	
D37. How much did you pay male workers?	
D38. How much did you pay female workers?	

HARVESTING	
D39. How many days did it take to harvest	
D40. How many males from the household were involved? On average, how long did each work per day?	
D41. How many females from the household were involved? On average, how long did each work per day?	
D42. How many male workers were involved? How many days did they work?	
D43.How many female workers were involved? How many days did they work	
D44. How much did you pay male workers?	
D45. How much did you pay female workers?	
POST HARVEST ACTIVITIES	
D46. How many days did it take for you to finish post-harvest activities?	
D47. How many males from the household were involved? On average, how long did each work per day?	
D48. How many females from the household were involved? On average, how long did each work per day?	
D49.How many males were hired for the task? How many days did they work?	
D50. How many females were hired for the task? How many days did they work?	
D51. How much did you pay male workers for the task?	
D52. How much did you pay female workers for the task?	

E. Conservation Agriculture

E1. Do youpractice no tillcultivation?	0 = no, 1 = yes **IF NO SKIP TO E4**
E2. If yes, for how long have you been practising it?	
E3. What is the estimated size of the farm on which you practice no-till cultivation?	
E4. Do you practice soil cover on your farm?	0 = no……………. **SKIP TO E6** 1 = yes
For how long have you been practising soil cover?	
E5. What is the estimated plot size on which you practice soil cover?	
E6. Do you practise crop rotation?	0 = no…………… **SKIP TO E8** 1 = yes
E7. For how long have you been practising rotation?	
E8. Do you practice intercropping?	0 = no................. **SKIP TO E10** 1 = yes
E9. If yes, for how long have you been practising intercropping?	
E10. In your own opinion, do you think that your household has benefitted in any way from adopting these conservation farming practices?	0 = no…………..**SKIP TO F1** 1 = yes
E11. If yes, how have you benefitted from these farming practises?	(a) Improves soil fertility (b) Reduces labour requirement (c) Improves yields (d) Reduce soil erosion (e) Other (specify)

F. Consumption and expenditure on maize

F1. On average, how many 50 kg bags of maize does your household consume per month under normal circumstances?	
F2. When faced with dry spells, on average how many 50 kg bags does your household consume?	
F3. In a normal year, how long does it take before you before you exhaust the maize stocks that you produce?	
F4. In a normal year how many bags of maize do you buy from the market?	
F5. At what price did you buy maize last year?	
F6. When faced with dry spells, how long does it usually take your household before it exhausts its stock of maize?	
F7. The last time there were dry spells, at what price did you buy maize?	
F8. As a farming household, how do you respond when you are faced with dry spells in the middle of the farming season?	

G. Knowledge assessment for adaptive capacity

G1. In your opinion, do you think you use land and water resources in appropriate ways that benefit the community in general?	0 = no 1 = yes………. **SKIP TO G3**
G2. If not why do you think so?	(1) Lack extension/ training (2) Lack of inputs (3) Lack of markets (4) Other (specify)
G3. If yes, what do you think could be the cause(s)?	(1) Have markets (2) Receive extension/training (3) Have inputs (4) Other (specify)
G4. Does this community experience dry spells?	(0) no………**SKIP TO G6** (1) yes

G5. How frequent do dry spells affect this community?

Same year	**over 5 yrs**	**over 10 yrs**

G6. When was the last time a dry spell that affected this community?	
G7. Was your farm affected in any way?	0 = no 1 = yes
G8. How was your farm affected?	
G9. What proportion of your farm was affected?	
G10. Did the dry spell have any effect on your maize output?	0 = no 1 = yes
G11. How was the maize output affected?	
G12. In general, when you have prior knowledge that there will be a dry spell, what measures does your household take to produce food? (coping strategies)	(1)get piece works/ganyu (2) beg for food (3) migrate (4) other (specify)
G13. Over a period of time, how has your household adjusted itself to dry spells that affect food production?(adaptive strategies)	(1) plant drought resistant crops/varieties (2) diversify crop production (3) livelihood diversification (4) adopted conservation agriculture (5) other (specify)

H. Household asset endowment

H1. Does this household own any of the following assets?

Asset type	**Number available**	**Would you sell asset(s) to buy food?**
Bicycles		0 = no, 1 = yes
Motor-cycles		0 = no, 1 = yes
Radios		0 = no, 1 = yes
Television		0 = no, 1 = yes
Beds		0 = no, 1 = yes
Chairs		0 = no, 1 = yes
Tables		0 = no, 1 = yes
Axes		0 = no, 1 = yes
Panga knives		0 = no, 1 = yes
Hand hoes		0 = no, 1 = yes
Ducks		0 = no, 1 = yes
Chickens		0 = no, 1 = yes
Rabbits		0 = no, 1 = yes
Goats		0 = no, 1 = yes
Pigs		0 = no, 1 = yes
Sheep		0 = no, 1 = yes
Cattle		0 = no, 1 = yes
Ox-carts		0 = no, 1 = yes
Sprayers		0 = no, 1 = yes
Treadle pumps		0 = no, 1 = yes

I. sources of income

Source	Who earned	Which month	Quantity/amount	Unit	Unit Price	Income (Kwacha)
I1. Sale of crops						
I2. Sale of livestock						
I3. Hired out labour						
I4. Employment						
I5. Rented out land						
I6. Food for work						
I7. Remittances						
I8. Food aid						
I9. Sale of handicrafts						
I10. Gifts/assistance						
I11. Sale of handicraft						
I12. Provision of services						
I13.Bicycle transport						
I14. Sale of beer						
I15.Other (specify)						

J. Existence and strength of social networks in the community

J1. When you get affected by dry spells, do you get any type of support from community members or neighbours?	0 = no, 1 = yes
J2. If yes, what type of support do you usually receive?	(1) Food (2) Money (3) Farm inputs (4) Other (specify)__________________
J3. How does this assist access to food in your household?	
J4. Has this household ever borrowed money to buy food?	0 = no, 1 = yes
J5. When did you last borrow money to buy food?	

J6. If yes, how much money has been borrowed?	
J7. How much money has been borrowed?	
J8. If no, did this household ever want to borrow any money to buy food?	0 = no, 1 = yes
J9. In general, do you think that you have somewhere to access credit when you need it?	
J10. Does any member in this household participate in microfinance activities of any kind?	0 = no, 1 = yes
J11. If yes, what type of microfinance activities is the member involved?	
J12. In total how many community organisations does the household participate in?	

K. Social services

K1. What is the most common means of transport that you use?	
K2. How long does it take you to travel from this household to the nearest market using this mode of transport above?	(1) Daily market………………minutes (2) Weekly market…………….minutes (3) ADMARC…………………minutes
K3. How accessible is the road to market from this community during the rainy season?	(0) Not accessible at all (1) Accessible
K4. What services are available in this community that support farmers to access markets?	(a) Extension (b) Marketing (c) Credit (d) Storage (e) Transport (f) Other (specify)
K5. What do you think are the main services that are lacking in this community	(a) Extension (b) Marketing

to facilitate market access by smallholder farmers?	(c) Credit (d) Storage (e) Transport (f) Other (specify)
K6. Does anyone in this household belong to farmer group(s)?	0 = no, 1 = yes
K7. If yes, what type of farmer group(s)?	(a) Clubs (b) Cooperatives (c) Other (specify)
K8. What are the main services that you get?	(a) Extension (b) Marketing (c) Credit (d) Storage (e) Transport (f) Other (specify)

End of Questionnaire; thank you for your time!!!