ANALYSIS OF ADAPTATION TO CLIMATE VARIABILITY AND CHANGE IN UGANDA: A GENDER AND HOUSEHOLD WELFARE PERSPECTIVE

Madina Guloba

PhD. (Economics) Dissertation
University of Dar es Salaam
September, 2014

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By

Madina Guloba

A Dissertation Submitted in Partial Fulfilment of the Requirement for the Degree of Doctor of Philosophy (Economics) of the University of Dar es Salaam

University of Dar es Salaam
September, 2014

CERTIFICATION

The undersigned certify that he has read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation entitled: ***Analysis of adaptation to climate variability and change in Uganda: A gender and household welfare perspective***, in partial fulfilment of the requirements for the degree of Doctor of Philosophy (Economics) of the University of Dar es Salaam.

....

Dr. Razack Lokina

(Principal Supervisor)

Date:..

DECLARATION

AND

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I, **Madina Guloba**, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Signature: ....

ACKNOWLEDGMENT

I have been fortunate to complete my PhD at the University of Dar es Salaam. The friendly and inspiring environment at the Department of Economics has greatly assisted my work. The work in progress benefited enormously from the entire Group E of the African Economic Research Consortium (AERC) Biannual conferences, 2012. I especially thank the useful input received from Professor Jane K. Mariara who was my resource person, and Dr. Precious Zekhali. In addition, I have enjoyed fruitful discussions at the International Association for Feminist Economists (IAFFE) conferences held at the University of Barcelona, 2012and Stanford University, 2013where IAFFE funded my attendance. I am grateful for the time spent as a PhD intern at UNU-WIDER, Helsinki-Finland in 2013. I had interactions with WIDER staff and got good feedback from the UNU-WIDER internal seminar series.

Most importantly, I am very grateful to the AERC for funding my PhD studies. The generous funding enabled me to focus solely on my studies and research. I have also received financial support for this research from the Environment for Development-Tanzania (EfD-T), University of Dar es Salaam.

I would like to express my sincere gratitude to my supervisor Dr. Razack Lokina who agreed to supervise my dissertation. Throughout my research, he has shown great professionalism, patience and support. His comments have always been to the point. No matter how busy, he has always found time for discussions. Our communication through email has been effective in enabling me to complete work on time away from the University. This pushed me to work even harder.

This dissertation benefited enormously from comments of Prof. Asmerom Kidane who is my “invisible supervisor” and Dr. Ronald Chifamba. I thank Dr. Elias Luvanda, the discussant during the presentation made in the advanced PhD seminar series, for the useful and insightful input. In addition, I would like to thank all my lecturers of the Collaborative PhD programme.

I am grateful to the various persons and institutions who helped me access data: The World Bank and the Uganda Bureau of Statistics for availing me the Uganda National Panel Survey dataset, Department of Meteorology, Ministry of Water and Environment especially Peace H for compiling the dataset, William George Omony for his input in analysing climate change, Commissioner Paul Isabirye, Coordinator- Climate Change Unit, Geo Information Officers, Charles Kyegonza and Joel Kitutu at the GIS department, Uganda Bureau of Statistics, Dr Sarah Ssewanyana, Executive Director, Economic Policy Research Centre, Uganda, Dr. Eria Hisali and Dr. Asumani Guloba for reading my draft proposal.

I am very lucky to have friends who not only are invaluable as friends but also top economic researchers in their fields. Thank you Deogratious Macha, Zerayehu Sime

Eshete, James Sandy Fomba, Dale Mudenda and Vincent Mboucthung for your advice, support, comments and proof reading my work. I thank all my classmates at the University of Dar es Salaam Class of 2010 and those at the Joint Facility for Electives econometric and environment classes of 2011. I am also grateful for the wonderful company of colleagues at UDSM/Economics Department/Wooden Block.

I also thank my very close friends. I am also very much obliged to my entire family for providing such a supportive environment to grow up and just be me. Special thanks go to by brothers for helping me run my home projects smoothly.

Above all, I thank the Almighty Allah (SW) for having made all this possible.

DEDICATION

To my family

ABSTRACT

The study establishes the extent to which climate change has occurred in Uganda, analyses choices of adaptation strategies to climate change induced shocks and factors determining the choices made at the household level by gender of the decision maker of the household, and lastly estimates the impact of adaptation strategies employed to covariate shocks on household welfare. More specifically, analysis of climate variability and change using meteorological data from 13 weather stations across Uganda reveals that Uganda's climate is varying and changing from the norm. Observations are made from the altered rainfall, temperatures, onset and cessation of rainfall patterns, and increases in occurrences and persistence of climate disasters such as floods and droughts, with negative impacts on the economy and households. Furthermore, utilising micro-level data for a balanced panel of 2,566 original households surveyed in 2005/06 and 2009/10, we identify the choices of adaptation strategies employed in response to climate disasters for both male and female headed households and in addition use a standard pooled Multinomial Logit model (MNL) to examine heterogeneity in factors influencing these choices in both households. Findings show that female headed households reduce consumption through scaling back food intakes and skipping meals while male headed households resort to use of savings as immediate adaptation strategies to drought. However, during floods, female heads increase labour supply and male heads reduce consumption in both surveys. All households use agricultural related technology when faced with crop pests' attacks. Livestock epidemics drive female headed households to expand labour supply and male headed households to rely on savings through sale of livestock at lower market prices. Generally, agro ecological climate zones in which households live play a key role in various adaptation options to shocks, irrespective of the gender of the household head. Findings point to the need for policy to have separate long term adaptation mechanisms that are gender sensitive. Lastly, we examine heterogeneity in impacts of adaptation strategies to covariate shocks on household welfare using Pooled OLS regression techniques and IV-2SLS method to address endogeneity in regressors. We use consumption expenditure per adult equivalent to proxy for household welfare. Findings show that not all adaptation techniques employed by households for a given climate shock have positive impacts on welfare. Specifically, adaptation strategies employed during drought and floods have a negative impact on welfare, while those employed during livestock epidemics impact positively on welfare. Such findings suggest that the choices of adaptation strategies are behavioural, highly risky and unsustainable leading to further vulnerability of many households especially the poor and those involved in agriculture.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Climate change will bring with it increased frequency of natural disasters that affect agriculture and rural households. It will alter temperatures and rainfall patterns, thereby changing farming practices and household behaviour" Yamauchi and Quisumbing (2009)

Worldwide climate change is being acknowledged and climate governing bodies have documented the means through which climate change is manifesting itself [1]. Understanding climate change and its impacts on well-being requires an even deeper understanding of the composition and drivers of climate. The Intergovernmental Panel on Climate Change (IPCC) indicates that analysing any changes in climate requires statistical description in terms of the mean and variability of quantities such as temperature, humidity and rainfall over a period of time ranging from months to thousands of years[2] (IPCC, 2001; 2007). Observable changes in climate[3] are affecting millions of individuals/households especially those involved in agricultural activities as agriculture largely depends on nature. In Uganda, about 77 percent of the country setting is rural and more than 75 percent of the people residing in rural areas depend on agriculture (UBoS, 2006; 2010). Yet, to my knowledge, no study in Uganda has

[1]See IPCC reports for 2001; 2007 and 2012.
[2] Climate change is used to indicate a significant variation (in a statistical sense) in either the long term mean state of the climate or in its variability for an extended period of time. The norm is 30 years as defined by the World Meteorological Organization (WMO).
[3]Uganda's temperatures are likely to increase by up to 1.5 ^{0}c in the next 20 years and by up to 4.5 ^{0}c by 2080 due to climate change and rainfall will increases by 10-120 percent over the same period over most of the country (IPCC, 2007).

attempted to analyse the extent of climate change whose impacts affects households especially dependent on agriculture. With increasing concern over changes in the patterns of climate, such incidences are likely to hasten the already high vulnerability of households in rural areas, thus posing a serious challenge to development efforts. With persistent threats of climate change especially on the poor, it is critical to have a deeper understanding of climate change patterns and choices of adaptation[4] strategies that households are undertaking as they cope with a changing climate.

As earlier mentioned, predictable climate is relatively more important to the poor than the non-poor in sub Saharan economies due to the poor's heavy reliance on nature dependent agricultural activities. For example, key changes in climatic conditions that include unpredictable rainfall, flooding and more frequent droughts (Tompkins and Adger, 2004) will affect the poor (high vulnerability) more than the non-poor and agricultural households as they are more vulnerable to climate distortions. Skoufias et al. (2011) argue that the non-poor are likely to recover faster than the poor due to the ease within which they access their social networks during disasters. Uganda has recorded 13 droughts in the period 1991 to 2006 alone (UNAPA, 2007). In addition, Uganda experienced severe floods in 1961/62, 1997/98, 2007 and in 2010. All these disasters affect food production, damage infrastructure, displace and destruct livelihoods. More so, the threats geared towards household security with significant gender implications

[4] Adaptation/response change refers to adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001).

because of the different roles, needs, capacities and positioning of men and women in society (Nampinga, 2008). As a consequence women and men are exposed to similar natural disasters but the degree of impacts felt and nature of coping strategies taken are not gender neutral. Recognition of this has led to the inclusion of gender considerations in adaptation to climate change policy agenda in recent years (IPCC, 2012).

In Uganda, gender relations is an area of concern with regard to climate change, as it contributes to the level of vulnerability a household faces and the possible choices of responses taken to climate change distress events (Denton, 2002). Therefore, a gender perspective in adaptation to climate change can moderate impacts and secure benefits (Nampinga, 2008; Orindi and Erikessen, 2008). Women's triple gender roles of reproduction, economic and social roles, and their responsibilities including providing for their households and engagement in livelihood strategies make them the cornerstone of household welfare even in a male headed household (UN-HABITAT, 2009). For instance, in times of drought and water stress, women walk long distances in search of water for their families which reduces their opportunities to engage in productive activities. Furthermore, unequal power relations between women and men lead to differences in their access to environmental resources and opportunities for income diversification, for example in wood sawing, game hunting, acquiring medicinal plants. Hence, environmental vulnerability, and indeed security, affects women and men differently, although, both play important roles in adaptation against climate distress events.

Several studies have focused on the impact of climate change and some on adaptation. Thus, research on adaptation to climate change extremes is on the rise (Adger et al., 2003; Orindi and Erikessen, 2008; Piya et al., 2012). Yet, few studies have examined factors influencing choice of adaptation strategies at case (farm) study level (Deressa et al., 2008; Gbetibouo, 2009; Below et al., 2010) and country level (Hisali et al. 2011). Further, the gender focus of these studies is inadequate. For example, existing studies on gender and adaptation to climate change are theoretical (Denton, 2002; Aguilar, 2008; Brody et al., 2008). Yet, arguments show that women and men have responded, and will always respond to climate perturbations in many different ways depending on the context (Denton, 2002; Aguilar, 2008; Muhanguzi et al., 2012). Empirical analysis of choice of adaptation strategies with a gender focus at country level is hard to find. However, Nabikolo et al. (2012) attempt to address this gap in research but their focus on adaptation is limited. More succinctly, to our knowledge, no study has empirically focused on gender and adaptation to climate change at country level in Uganda. Therefore, this study fills this research gap and contributes to the growing body of literature using the Uganda national household panel survey datasets.

Similarly, literature has largely focused on the impact of climate change shocks on welfare (Eakin, 2000; Okuyama, 2009; Thomas et al., 2010; Skoufias et al, 2011) and to our knowledge, none on the impact of adaptation to climate shocks on welfare. Di Falco et al. (2011) attempt this, but focus on the impact of adaptation (a binary variable) on household food security.

1.2 Statement of the problem

Most of the debate on climate change for the past 15 years has been on the impact of climate change rather than the role of adaptation. Although evidence indicates that climate change is actually occurring in many parts of Uganda, there is limited empirical analysis to ascertain this. Specifically, climate change analysis in economic literature in Uganda has mainly focused on analysis of climate variability (of temperature and rainfall indicators), which cannot be a bench-mark for concluding that variability in these indicators imply climate change. As a result, there is no in-depth and conclusive analysis on the extent to which climate, which is naturally expected to vary over a long period of time, has indeed changed to warrant cause for worry not only for the average Ugandan farmers but for the country in general as new policy mandates are drafted and the old ones revised.

In response to climate change perturbations, households are undertaking “impromptu” or “last resort” coping measures. It has been widely acknowledged that climate change has adverse impacts that are not gender neutral. How? Decision making processes at the household level are said to be heterogeneous depending on the gender of the “final decision maker or household head” despite households being in the same locality and facing similar risks on a day-to-day basis. Such important implications though explored in Uganda, where climate change has been given a gender perspective in the policy arena and research, has never been quantified on a national scale and research in general. More so, on the factors that influence a household’s choice of adaptation strategies employed by gender of the household head. We believe that such limitation in evidence-based research is undermining the implementation and enforcement of many of Uganda's policies that currently emphasise engendering outcomes.

In addition, whereas efforts to quantify the impact of climate change on welfare have been made, similar efforts to empirically analyse the impact of choice of adaptation strategies to climate change shocks on household welfare have not been carried. Thus, this study contributes to literature by examining household welfare-adaptation strategies linkage at the household level. On the policy front, despite Uganda ratifying to regional and global obligations on gender, there is limited assessment on the extent to which current policies and programmes address environment, climate change and the gendered impact of climate change. That is, it is not clear how the draft climate policy will address the implementation and enforcement of environmental regulations that indirectly influence climate, affect welfare and gender. It is against this background that the study first analyses the extent of climate variability and change then, identifies choices of adaptation strategies to covariate shocks employed and factors determining these choices by gender of the household head and finally, examine the impact of adaptation strategies by covariate shock on household welfare.

1.3 Objectives of the study

The study's broad objective is to provide empirical evidence on how gender shapes choices of adaptation strategies undertaken as a result of climate change induced shocks and analyse the impact of adaptation strategies employed on household welfare. The study is guided by the following specific objectives:

i. Empirically analyse Uganda’s climate and how it has changed over time;

ii. Examine the extent to which gender of the decision maker of the household influences choice of adaptation strategies employed and factors determining the adaption process; and

iii. Quantify and analyse the impacts of coping strategies to climate distress events on household welfare.

To address the above objectives, the study seeks to answer the following questions:

i. What are the key drivers of climate variability and change in Uganda?

ii. To what extent has climate change altered climate indicators from the natural expected variability over time?

iii. What are the types and frequency of climate shocks affecting households?

iv. In response to the shocks, what are the coping strategies female and male headed households utilising and, what are the factors determining the observable differences in choice of adaptation strategies to climate shocks by gender?

v. Which vector of coping strategies choices by climate shock impact on welfare greatly?

vi. Which categories of households experience higher welfare impacts as a result of adaptation measures employed when climate shocks occur?

1.4 Significance of the study

Climate is changing but country level analysis and understanding of climate variability and change is limited. In addition, differences in gender roles at household level due to institutional, cultural and societal construction/frameworks that govern Ugandan households are increasingly being recognised as an important area of focus in the study of climate change and adaptation. Furthermore, identification of the determinants of choices of adaptation strategies to climate change distress events by gender and the impact of adaptation on welfare cannot be underscored. By throwing light on these issues, novel insights from the study findings will, first, increase the understanding in the analysis of climate change and its determinants. Second, increase awareness of the role of gender in adaptation in order to improve gender and climate policies. In other words, long term coping mechanisms implementation efforts if they are to be scaled up can be appropriately targeted using evidence from this study. Third, since the study delves into new grounds on estimation of the impact of adaptation strategies on welfare, this result is important to the public and policy-makers through the incorporation of demand-side information into the design of the climate policy agenda and the roles of the key stakeholders in the implementation process. In general, the study adds novel literature on climate change and adaption in general, and in particular, the role of gender and welfare in relation to adaptation to climate change debate.

1.5 Scope

The study area is Uganda. According to UBoS (2012), Uganda has a total area of 241,550.7 square kilometres (sq. kms) and is located between latitudes 1.5^{0} S to 4.5^{0} N and longitudes $29^{0}34$'E & $35^{0}0$'E. Open water and swamps cover 41,743.2 sq. kms and land area is 199,807.4 sq. kms with cultivated land cover increasing from 84,010 sq. kms in 1990 to 99,018.4 sq. km in 2005. Furthermore, Uganda is characterised by high terrain, for example Mt. Rwenzori (5100 M), the south western highlands to the west and Mt. Elgon (4321 M) and Moroto (3084 M) to the east. It contains several inland water bodies like Lake Victoria and Lake Kyoga and several other lakes which lie in the Western Rift Valley e.g. L. Albert, L. George, L. Edward and L. Katwe among others. These physical features modify the spatial and temporal variations of the country's climate.

On the other hand, Uganda has a total population (2012 mid-year) of 34.1 million[5] of which the urban population is 14.7 percent and sex ratio of total population was 95 males per 100 females (UBoS, 2012). Generally, nearly 7.5 million Ugandans, living in 1.2 Million households, were considered poor in 2009/10. The proportion of the poor population reduced from 31 percent in 2005/06 to 25 percent in 2009/10. And lastly, with regard to labour force status, 79 percent of the working population-between 14 and 64 years-in 2009/10 were self-employed and 21 percent were paid employees. Agriculture sector engages 66 percent of the working population (UBoS, 2012).

[5] Demographic estimates are based on the Census 2002 final results. Only population of gazetted city, municipalities and towns is considered as urban population.

Uganda was chosen for this study because of available data to carry out the research objectives and due to the relatively added advantage that the author is more familiar on the country's dynamics and institutional frameworks.

1.6 Outline of the dissertation

The study comprises of six chapters. Chapter 2 reviews gender, welfare and climate in Uganda with a focus on trends and policies. Chapter 3 provides an analysis of climate variability and change in Uganda. Chapter 4 discusses adaptation to climate change in Uganda with a gender perspective. Chapter 5 analyses adaptation to climate change in Uganda with a household welfare perspective. And finally, Chapter 6 concludes by providing a summary of key study findings, policy recommendations, limitations and suggestions for future research.

CHAPTER TWO

GENDER, WELFARE AND CLIMATE IN UGANDA: TRENDS AND POLICY REVIEW

2.1 Introduction

Uganda is a country whose economy relies heavily on its major agricultural cash crops (especially coffee), and is thus among the sub Saharan African countries that are vulnerable to climate change (UNFCCC, 2006). The country is apparently vulnerable to climate change hazards due to her low adaptive capacity to adverse effects there from. The adverse effects of climate change in Uganda include frequent and persistent droughts and floods. These have increased in occurrence in the last few decades. According to MAAIF (2008) report, Uganda is characterised with rampant poverty, weak institutional capacity, lack of skills on climate change adaptability and inadequate skills in disaster management, lack of equipment for disaster management, limited financial resources and above all an economy which depends entirely on exploitation of its natural resources such as use of forest trees for timber, medicinal value, clear forest cover for agricultural production. Thus, in this chapter, discussed are the economic and climate trends, policy and legal framework. In particular, we review the extent of inclusion and recognition of climate change, gender and welfare in policy debate and discuss their weakness in the institutional framework.

2.2 Overview of Uganda's socio-economic status and climate

2.2.1 Uganda's socio-economic status

Uganda has registered strong economic growth with Gross Domestic Product (GDP) growth rate averaging 7.6 percent for the past seven years (Table 2.1). Specifically, the Ugandan economy grew by 5.5 percent in 2009/10 which is 1.8 percentage points less than the growth rate of 7.3 percent achieved in 2008/09 and grew by 6.3 percent in 2010/11, 0.8 percentage points more than that achieved in 2009/10 (Table 2.1). Although there was a slowdown in the growth rate of GDP, it was nevertheless robust given that the country faced adverse external shocks as well as natural disasters during 2008/09, 2009/10 and 2010/11. Industry grew by 7.5 percent, services 8.0 percent and 0.9 percent for the agricultural sector in 2010/11.

In terms of contribution to total GDP, the share of agriculture, forestry and fishing in total GDP at 2002 constant prices continued to decline from 15.1 percent in 2008/09 to 14.7 percent in 2009/10 to 13.9 percent in 2010/11. This decline was in line with recent trends in structural transformation of the economy. The services and industrial sectors are continually becoming the major drivers of growth, and the share of industry increased from 25.0 percent to 25.3 percent in FY2009/10 and 2010/11 respectively at constant (2002) market prices (UBoS, 2012; MoFPED, 2012).

Table 2.1: GDP growth rate by economic activity at constant (2002) prices

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
Total GDP at market prices	**6.3**	**10.8**	**8.4**	**8.7**	**7.3**	**5.5**	**6.3**
Agriculture, forestry and fishing	**2.0**	**0.5**	**0.1**	**1.3**	**2.9**	**2.4**	**0.9**
Cash crops	-5.5	-10.6	5.4	9.0	9.8	-1.1	-15.8
Food crops	-0.2	-0.1	-0.9	2.4	2.6	2.7	2.7
Livestock	3.0	1.6	3.0	3.0	3.0	3.0	3.0
Forestry	6.5	4.1	2.0	2.8	6.3	2.9	2.8
Fishing	13.5	5.6	-3.0	-11.8	-7.0	2.6	0.4
Industry	**11.6**	**14.7**	**9.6**	**8.8**	**5.8**	**6.5**	**7.5**
Mining & quarrying	27.2	6.1	19.4	3.0	4.3	15.8	15.8
Manufacturing	9.5	7.3	5.6	7.3	10.0	6.6	6.5
Formal	11.8	7.8	4.9	9.2	12.0	6.1	7.2
Informal	3.6	6.0	7.0	2.1	4.4	8.2	4.3
Electricity supply	2.1	-6.5	-4.0	5.4	10.6	14.5	13.1
Water supply	3.9	2.4	3.5	3.8	5.7	4.4	4.1
Construction	14.9	23.2	13.2	10.5	3.7	5.9	7.7
Services	**6.2**	**12.2**	**8.0**	**9.7**	**8.8**	**7.4**	**8.0**
Wholesale & retail trade; repairs	7.2	12.3	10.4	14.7	9.7	0.7	3.0
Hotels & restaurants	6.5	8.7	11.3	10.7	4.5	4.5	4.1
Transport & communication	9.8	17.1	17.7	21.3	14.3	17.5	15.9
Road, rail & water transport	6.7	12.8	9.5	20.8	12.9	14.1	7.7
Air transport & support services	19.4	6.9	13.8	17.8	-3.6	0.9	2.1
Posts and telecommunication	11.8	26.2	29.1	22.6	19.8	23.7	21.2
Financial services	13.0	31.7	-11.9	17.1	25.4	36.1	10.3
Real estate activities	5.5	5.6	5.6	5.6	5.7	5.7	5.7
Other business services	9.2	12.5	8.0	10.8	12.4	15.0	7.8
Public administration & defence	-5.4	15.8	-6.3	12.1	5.5	6.9	12.0
Education	4.4	9.4	10.6	-6.5	4.3	-1.5	10.7
Health	5.6	12.9	2.7	-4.8	-3.2	11.9	12.6
Other personal & community services	15.0	14.1	13.4	12.8	12.3	11.8	11.4
Adjustments	**3.4**	**17.6**	**27.9**	**17.5**	**10.2**	**-2.7**	**2.3**
FISIM	39.2	34.2	13.8	15.9	27.1	69.1	27.0
Taxes on products	6.7	19.5	22.3	17.3	11.8	5.0	6.6

Note: FISIM-Financial Intermediation Services Indirectly Measured
Source: Uganda Bureau of Statistics, Statistical Abstract, 2012

Furthermore, Table 2.1 shows the growth rates of various sectors and subsectors of GDP, and it clearly highlights the poor performance of cash crop subsector (-15.8

percent), air transport and support services (2.1 percent), both sectors are vulnerable to global economic trends. In particular to cash crops, the landslides/mudslides in the Mt. Elgon slopes in 2009/10 and 2010/11 a major coffee producing region and sporadic rains and prolonged dry spells in many parts of cotton growing areas led to the general poor performance of cash crops. The main factors that collectively led to a slowdown in the rate of growth of GDP include the changing climate and the consequent natural disasters, external shocks, and reduction of exports to South Sudan (UBoS, 2012 and MoFPED, 2012).Uganda has witnessed various naturally triggered and human induced disasters, examples of which include earthquakes, landslides/mudslides, floods, construction accidents, fires, ethnic conflicts and wars, drought and pests (OPM, 2007). The relief and rehabilitation phases of disaster responses have previously been the main focus of disaster management in the country.

2.2.2 Uganda's climate, definitions and drivers

2.2.2.1 Overview of Uganda's climate

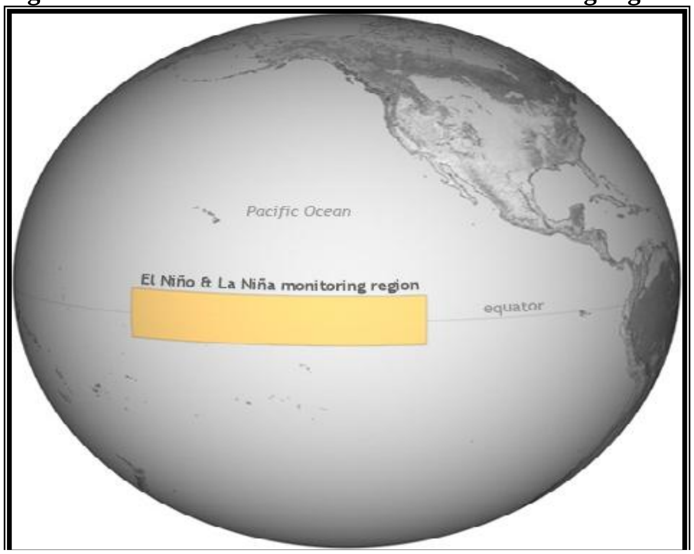
Uganda experiences tropical climate as it lies along the Equator. It generally has two rainy seasons (March to May, September to November) and two dry seasons (December to February, June to August). Although Uganda is on the equator, its climate is warm and humid and average temperatures vary little throughout the year. Temperature generally varies by altitude. For instance on Lake Albert, the mean annual maximum temperature is 29° C (84° F) and the mean annual minimum temperature is 22° C (72° F). In Kabale in the southwest, 1,250 m (4,100 ft) higher, the mean annual maximum temperature is 23° C (73° F), and the mean annual minimum temperature is 10° C (50° F). In Kampala, temperatures range between 27° C (81° F) and 17° C (63° F) (NEMA, 2007). Most of the territory receives an annual rainfall of at least 100 cm (UDoM, 2012).

2.2.2.2 Understanding climate definitions and drivers

Global context

No single climate phenomenon has more influence on year-to-year variation in average global temperature than the El Niño-Southern Oscillation (ENSO). When the central tropical Pacific Ocean is warmer than average (El Niño) or colder than average (La Niña) a cascade of atmospheric changes ensures that many parts of the globe feel the effects. The US National Oceanographic and Atmospheric Administration's (NOAA) Climate Prediction Center, the branch of the agency responsible for monitoring and forecasting ENSO events point out that ENSO-related temperature fluctuations in the tropical Pacific that have such far-reaching impacts on seasonal climates downstream aren't about a *specific* temperature. Instead, they are about relative temperatures, one region being hotter or colder than usual, and the climate chaos that ensues when things are not "normal". The Niño 3.4 region is the area of the Pacific Ocean where observed Sea Surface Temperature (SST) is compared to average SST to calculate the Oceanic Niño Index (ONI). The region spans a swath from 5^0N to 5^0S latitude and 120^0W and 170^0W longitude (Figure 2.1).

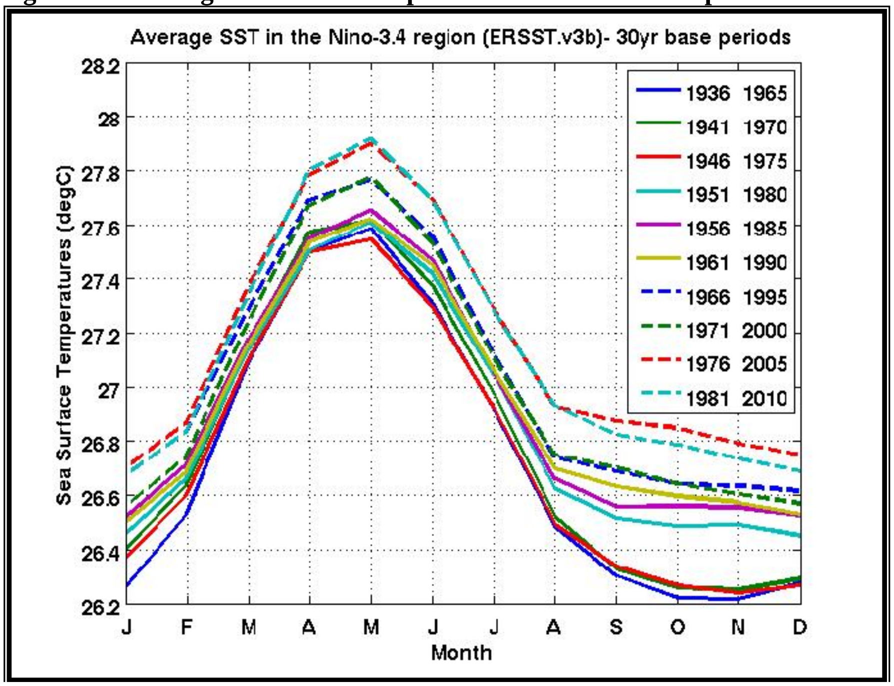
Figure 2.1: El Niño Southern Oscillation monitoring region



Source: NOAA's Climate Prediction Center, 2012

Due to a significant warming trend in the Niño 3.4 region since 1950, El Niño and La Niña episodes that are defined by a single fixed 30-year base period (e.g. 1971-2001) are increasingly incorporating longer-term trends that do not reflect inter-annual ENSO variability. A centered 30-year base period means that El Niño and La Niña episodes will be defined by their contemporary climatology. If the climate weren't changing, the difference between 30-year averages would be very small, and the impacts on the apparent strength of historic El Niño and La Niña episodes would be negligible. But over the span of the past century, ocean temperatures have been getting warmer, which means that the baseline for detecting El Niño and La Niña has been shifting (Figure 2.2). Implying that, the average monthly temperatures in the central tropical Pacific have been increasing. Figure 2.2 shows the new 30-year averages that NOAA is using to calculate the relative strength of historic El Niño and La Niña events. The past three decades have been the warmest on record both globally and in the tropical Pacific.

Figure 2.2: Average sea surface temperature in the central tropical Pacific



Source: NOAA's Climate Prediction Center, 2012

Ugandan context

There are 12 global climate prediction centres designated by the World Meteorological Organisation (WMO) which work hand in hand with Regional Climate Centres (RCC) around the world. Uganda is a member of IGAD Climate Prediction and Application Centre (ICPAC) where it belongs to the RCC based in Nairobi, Kenya. Here, climate predications for three month seasonal forecasts are made for the countries in the greater horn of Africa.

Changes in climate in Uganda are largely determined by the conditions of the sea/oceans. Discussions with Uganda Department of Meteorology (UDoM) and climate change unit officials in June, 2012 reveal that predictions require several months of data and use of specific software packages. In addition, it requires a collection of many predictors such as wind indices, southern oscillation index, SSTs, baseline observations, Pacific, Atlantic and Indian oceans indicators to mention a few. Long term forecasts rely on probabilities and are not deterministic. The forecasts loose accuracy with time due to the chaotic nature of the atmosphere and growth of measurement error in the models. Implying that, a one month weather prediction is more accurate than three months prediction despite both forecasts being of a probabilistic form. Put somewhat differently, as the period gets longer and longer, forecasts loose meaning. The WMO under which the IPCC is housed is the only institution mandated to carryout climate predictions after so many consensus meetings have been held with various climate bodies established all over the World. As a result, throughout this study, we exclusively use available climate data for analysis and no climate change predictions are made.

Climate definitions

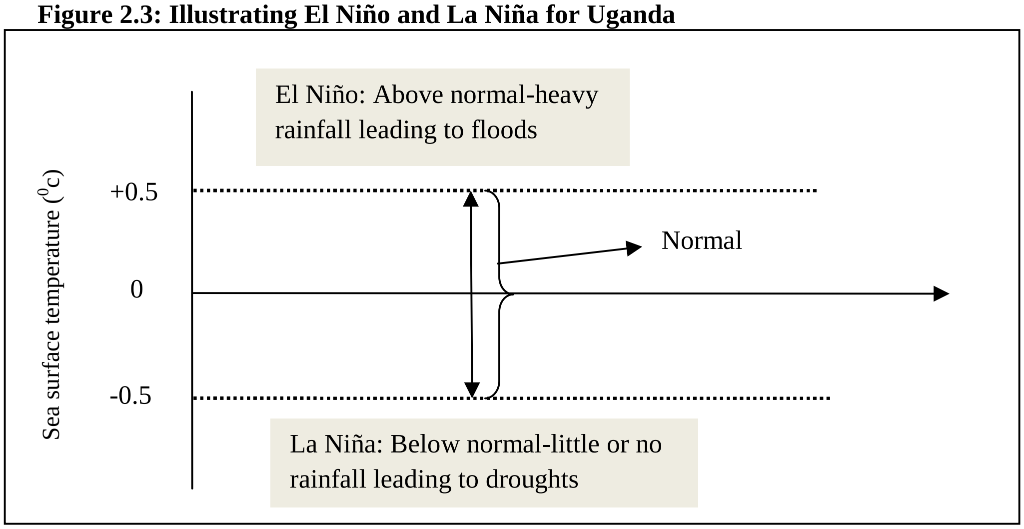
As earlier mentioned, anomalies in the SSTs over eastern and central tropical Pacific Ocean trigger weather and climate anomalies in many parts of the world, especially within the tropics where Uganda is located. Thus, in this study, climate variability and change analysis in the subsequent chapter cannot be complete without fully understanding two important climate terms: El Niño and La Niña. NOAA's operational definitions for El Niño and La Niña are:

i. El Niño: A phenomenon in the equatorial Pacific Ocean characterized by a ***positive/warm*** SST departure from normal (for the 1971-2000 base period) in the Niño 3.4 region greater than or equal in magnitude to 0.5°C, averaged over three consecutive months. For Uganda, there is a high correlation between El Niño events and normal or above normal rainfall during the two cropping seasons- usually leading to floods and landslides if prolonged.

ii. La Niña: A phenomenon in the equatorial Pacific Ocean characterized by a ***negative/ cold*** SST departure from normal (for the 1971-2000 base period) in the Niño 3.4 region greater than or equal in magnitude to 0.5°C, averaged over three consecutive months. There is a high correlation between La Nina events and below normal or poorly distributed rainfall over many parts of Uganda during October to December and March to May-usually leading to droughts if prolonged.

Figure 2.3, illustrates the above climate definitions better.

Figure 2.3: Illustrating El Niño and La Niña for Uganda



Source: Author's own based on WMO definitions

Thus, departures from average SSTs in the Niño 3.4 region (see Figure 2.1) are critically important in determining major shifts in the pattern of tropical rainfall, which influence the jet streams and patterns of temperature and precipitation around the world with varying chronic consequences. To derive the Oceanic Nino Indices shown in Table 2.2, seasonal three monthly average SST datasets with coverage in the tropical Pacific Ocean are analysed. From these SST datasets, the time series of three established SST regions are calculated, which are commonly used to monitor and predict the ENSO. The domains of these SST regions are averaged to form the Niño indices shown in Table 2.2. To filter out month-to-month variability, average SST in the Niño 3.4 region is calculated for each month and then averaged with values from previous month and following month. A "season" is any 3-month rolling average: December-January-February (DJF), January-February-March (JFM) and so on (see Table 2.2). This running three-month average value is compared with average SST for the same three months during 1981-2010. The departure from the 30-year average of the three-month average is known as the Oceanic Niño Index (ONI)[6] presented in Table 2.2 from 1980-2011. For La Niña or El Niño conditions to graduate to full blown episode, the temperature anomaly must last five consecutive over lapping seasons. To allow rankings and comparisons of all historic ENSO events, three long-lived events are colour-coded in the Climate Prediction Center's Table 2.2 of ONI: *blue*/*shaded* for "La Niña", *red/italics* for "El Niño" and *black* for "Niño Neutral".

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[6]Calculations of the ONI are well detailed in L'Heureaux et al. (2002). Linear trends in sea surface temperature of the tropical Pacific Ocean and implications for El-Niño-Southern oscillation. *Climate Dynamics*, 1-14.doi:10.1007/s00382-012-1331-2

Table2.2: Changes to the Oceanic Niño Index (ONI)

Year	DJF	JFM	FMA	MAM	AMJ	MJJ	JJA	JAS	ASO	SON	OND	NDJ
1980	0.5	0.4	0.3	0.3	0.4	0.4	0.2	0	-0.1	0	0	-0.1
1981	-0.4	-0.6	-0.5	-0.4	-0.3	-0.3	-0.4	-0.4	-0.3	-0.2	-0.2	-0.1
1982	-0.1	0	0.1	0.3	***0.5***	***0.6***	***0.7***	***1***	***1.5***	***1.9***	***2.1***	***2.2***
1983	***2.2***	***1.9***	***1.5***	***1.2***	***0.9***	***0.6***	0.2	-0.2	**-0.5**	**-0.8**	**-0.9**	**-0.8**
1984	**-0.5**	-0.3	-0.2	-0.4	-0.5	-0.5	-0.3	-0.2	-0.3	**-0.6**	**-0.9**	**-1.1**
1985	**-1**	**-0.9**	**-0.7**	**-0.7**	**-0.7**	**-0.6**	**-0.5**	**-0.5**	**-0.5**	-0.4	-0.4	-0.4
1986	-0.5	-0.4	-0.2	-0.2	-0.1	0	0.3	***0.5***	***0.7***	***0.9***	***1.1***	***1.2***
1987	***1.2***	***1.3***	***1.2***	***1.1***	***1***	***1.2***	***1.4***	***1.6***	***1.6***	***1.5***	***1.3***	***1.1***
1988	***0.7***	***0.5***	0.1	-0.2	**-0.7**	**-1.2**	**-1.3**	**-1.2**	**-1.3**	**-1.6**	**-1.9**	**-1.9**
1989	**-1.7**	**-1.5**	**-1.1**	**-0.8**	**-0.6**	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.1
1990	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.4
1991	0.3	0.2	0.2	0.3	***0.5***	***0.7***	***0.8***	***0.7***	***0.7***	***0.8***	***1.1***	***1.4***
1992	***1.6***	***1.5***	***1.4***	***1.2***	***1***	***0.7***	0.3	0	-0.2	-0.3	-0.2	0
1993	0.2	0.3	0.5	0.6	0.6	0.5	0.3	0.2	0.2	0.2	0.1	0.1
1994	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.4	***0.5***	***0.7***	***1***	***1.2***
1995	***1***	***0.8***	***0.6***	0.3	0.2	0	-0.1	-0.4	**-0.7**	**-0.8**	**-0.9**	**-0.9**
1996	**-0.9**	**-0.8**	**-0.6**	-0.4	-0.3	-0.2	-0.2	-0.3	-0.3	-0.3	-0.4	-0.5
1997	-0.5	-0.4	-0.1	0.2	***0.7***	***1.2***	***1.5***	***1.8***	***2.1***	***2.3***	***2.4***	***2.3***
1998	***2.2***	***1.8***	***1.4***	***0.9***	0.4	-0.2	**-0.7**	**-1**	**-1.2**	**-1.2**	**-1.4**	**-1.5**
1999	**-1.5**	**-1.3**	**-1**	**-0.9**	**-0.9**	**-1**	**-1**	**-1.1**	**-1.1**	**-1.3**	**-1.5**	**-1.7**
2000	**-1.7**	**-1.5**	**-1.1**	**-0.9**	**-0.8**	**-0.7**	**-0.6**	**-0.5**	**-0.5**	**-0.6**	**-0.8**	**-0.8**
2001	**-0.7**	**-0.6**	**-0.5**	-0.3	-0.2	-0.1	0	0	-0.1	-0.2	-0.2	-0.3
2002	-0.2	0	0.1	0.3	***0.5***	***0.7***	***0.8***	***0.8***	***0.9***	***1.2***	***1.3***	***1.3***
2003	***1.1***	***0.8***	0.4	0	-0.2	-0.1	0.2	0.4	0.4	0.4	0.4	0.3
2004	0.3	0.2	0.1	0.1	0.1	0.3	***0.5***	***0.7***	***0.7***	***0.7***	***0.7***	***0.7***
2005	***0.6***	0.4	0.3	0.3	0.3	0.3	0.2	0.1	0	-0.2	**-0.5**	**-0.8**
2006	**-0.9**	**-0.7**	**-0.5**	-0.3	0	0.1	0.2	0.3	***0.5***	***0.8***	***1***	***1***
2007	***0.7***	0.3	-0.1	-0.2	-0.3	-0.3	-0.3	**-0.6**	**-0.9**	**-1.1**	**-1.2**	**-1.4**
2008	**-1.5**	**-1.5**	**-1.2**	**-0.9**	**-0.7**	**-0.5**	-0.3	-0.2	-0.1	-0.2	-0.4	-0.7
2009	-0.9	-0.8	-0.6	-0.2	0.1	0.4	***0.5***	***0.6***	***0.7***	***1***	***1.4***	***1.6***
2010	***1.6***	***1.4***	***1.1***	***0.7***	0.2	-0.3	**-0.8**	**-1.2**	**-1.4**	**-1.5**	**-1.5**	**-1.5**
2011	**-1.4**	**-1.3**	**-1**	**-0.7**	-0.4	-0.2	-0.2	-0.3	**-0.6**	**-0.8**	**-1**	**-1**

Note: Warm (red/italics) and cold (shaded/blue) episodes are based on a threshold of +/- 0.5^{o}C for the Oceanic Niño Index (ONI) (3 month running mean of ERSST.v3b SST anomalies in the Niño 3.4 region (5^{o}N-5^{o}S, 120^{o}-170^{o}W)], based on centered 30-year base periods updated every 5 years. For historical purposes cold and warm episodes (blue/shaded and red/italics coloured numbers respectively) are defined when the threshold is met for a minimum of 5 consecutive over-lapping seasons.

Source: Climate Prediction Centre, 2012

2.2.2.3 Characterising climate extremes in Uganda

Over 70 percent of natural disasters/shocks in Uganda are related to extreme climate events such as strong winds, severe thunderstorms, droughts and floods among others and these are linked with the El Niño and La Niña (UMU, 2011). These extremes adversely affect the entire economy of which the poor are most affected. The risk faced from extreme climatic events depends on the degree of, and/or the intensity of the event, which can be determined from regular monitoring and analysis. According to UMU, (2011), extreme climate events that pose potential risk include: droughts, floods, landslides, hailstorms, thunderstorms, and lightning. In here, we focus on droughts and floods that induce new and persistent shocks such as crop pests and livestock epidemics.

Drought has many definitions but three are most common: (i) Meteorological Drought: This is a situation arising from deficiency of precipitation from that is expected over an extended period of time; (ii) Hydrological Drought: This is a deficiency in surface and subsurface water supplies; and (iii) Agricultural Drought: Deficiency in soil moisture (a critical factor in defining crop production). It should be noted that any form of drought originates from deficiency of rainfall (UMU, 2011).

Unlike many other natural disasters such as cyclones, floods and earthquakes, drought has some unique characteristics in that it does not destroy food storage, shelter or infrastructure. Yet, its impacts are higher in many developing countries, especially in Africa. It installs itself slowly and it is often difficult to detect it onset until some major impacts such as lack of water and food, start to be noticed. Its effects are cumulative. In Uganda, where rain-fed agriculture forms a major source of food and income, drought has severe effects on the welfare of communities, especially the poor. For example, shortages in rural and urban water-supply, crop failure which leads to food shortages and famine, livestock deaths, people and animals are forced to migrate in search of scarce water and food. This provokes conflict between humans and animals over limited water resources and pasture e.g. in Karamoja sub region due to conflict over animals, government has designed a disarmament program which has taken a slow process to bring peace and order in the region (Republic of Uganda, 2010).

On the other hand, floods result from prolonged, high intensity rainfall. Violent thunder showers which are of short duration produce flash floods. Flash floods are common in areas which experience heavy thunderstorms e.g. areas around Lake Victoria. Floods are made worse by anthropogenic changes in the catchment's areas in the form of urbanisation; various land-use changes like elimination of natural flood retention capacities (concrete and asphalt surfaces) and interference with natural drainage conditions (e.g. Nakivubo channel). Areas most under threat include flat low lying e.g. Kasese district located in the south west and Soroti district in the eastern parts of the country, urban areas like Kampala in the central region and suburbs (UDoM, 2011).

In order to contextualise climate variability, change and shocks for Uganda, we analyse changes in the Oceanic Niño Index (ONI) as provided by the Climate Prediction Centre

(CPC). Table 2.2 provides information on predictions for El Niño and La Niño and their implications for Uganda.

From Table 2.2, note that when above normal rainfall (red/italics) is predicted as a result of SSTs, Uganda will most likely experience above normal rains leading to floods in most parts of the country (see years 1982/83, 1987, 1991/93, 1994, 1997/98, 2002, 2004, 2006/07). On the other hand, below normal rains (blue/bold) if predicted, almost the whole country will experience very little or no rainfall coupled with high temperatures causing droughts (see years 1984/85, 1988/89, 1995/96, 1998-2001, 2007/08, 2010/11). Interesting to note is that in episodes where the country experiences El Niño (red/italics) most likely La Niña (blue/bold) follows months or a year later and vice versa. In 1997/98, after a yearlong severe flood, drought followed that lasted for three years ending in early 2001 (Table 2.2). This still is one of the worst floods the country has experienced since the mid-seventies (Republic of Uganda, 2010). Since then, in 2006/07 the country experienced another severe flood and according to anecdotal data from the National Disaster Preparedness Report (2010), the north eastern and some parts of the eastern regions of the country were the worst hit leaving about 300,000 people homeless, vulnerable, increased spread of water borne diseases, no education for school going children as school infrastructure and accessibility roads were destroyed. The frequency of such extreme weather events (floods and droughts) is on the increase (UNAPA, 2007) leaving many Ugandan households vulnerable as about 75 percent depend on agriculture which depends on nature (UBoS, 2012). This has gender and welfare implications in regard to food security and health as households devise adaptation mechanisms to climate shocks that directly impact negatively agriculture their main source of livelihood.

2.3 A review of relevant legislation and policies

2.3.1 Legislation review

2.3.1.1 The Constitution of the Republic of Uganda, 1995

Legislation of issues relating to gender, climate change and environmental conservation and sustainable natural resource management and conservation are provided for in the 1995 Constitution of the Republic of Uganda.

Section VI addresses gender balance and fair representation of marginalised groups, XV is on recognition of the role of women in society. Section XXII on natural disasters states that "the state shall institute an effective machinery for dealing with any hazard or disaster arising out of natural calamities or any situation resulting in the general displacement of people or serious disruption of their normal life" and XXVII addresses the environment in which its stated that:

(i) The state shall promote sustainable development and public awareness of the need to manage land, air and water resources in a balanced and sustainable manner for the present and future generations.

(ii) The utilisation of the natural resources of Uganda shall be managed in such a way as to meet the development and environmental needs of the present and future generations of Ugandans, and, in particular, the state shall take all possible measures to prevent or minimise damage and destruction to land, air and water resources resulting from pollution or other causes.

(iii) The state shall promote and implement energy policies that will ensure that people's basic needs and those of the environmental preservation are met.

(iv) The state, including local governments, shall: (a) Create and develop parks, reserves and recreation areas and ensure the conservation of natural resources; (b) Promote the rational use of natural resources so as to safeguard and protect the biodiversity of Uganda.

More specifically, chapter fifteen of the constitution addresses issues relating to land and the Environment. Land ownership is addressed in respect to many issues and environmental protection is one of them. That is Land in Uganda belongs to the Citizens of Uganda and shall invest in it in accordance with the land tenure systems provided for in this constitution. Notwithstanding clause (1) of this article: (a) the Government or local government may, subject to article 26 of this constitution, acquire land in the public interest; and the conditions governing such acquisition shall be as prescribed by Parliament; (b) the Government or a local government as determined by Parliament by law shall hold in trust for the people and protect natural lakes, rivers, wetlands, forest reserves, game reserves, national parks and any land to be reserved for ecological and futuristic purposes for the common good of all citizens. With regard to the environment, Article 245 on the protection and preservation of the environment states that Parliament shall, by law, provide for measures intended: (a) to protect and preserve the environment from abuse, pollution and degradation; (b) to manage the environment for sustainable development; and (c) to promote environmental awareness.

Chapter seventeen, Article 249 on Disaster Preparedness and Management Commission outlines that: (1) there shall be a Disaster Preparedness and Management Commission for Uganda to deal with both *natural* and *man-made* disasters. (2) Parliament, shall for the purposes of this article prescribe the composition, functions and procedure for implementation of the functions of the commission.

In this regard, a number of laws have been put in place to guide environmental and natural resource management and conservation in the country as presented below.

2.3.1.2 The National Environment Statute, 1995

“Environment” has been defined as the physical factor of the souring of human beings including land, water, atmosphere, climate, sound, odour, taste, the biological factor of animals and plants and the social factors of aesthetics and includes both the natural and the built environment. The National Environment Statute (NES) calls for the sustainable management of the environment of Uganda. It also establishes key institutions such as the National Environment Management Authority (NEMA), which is the supreme agency responsible for environment management; the District Environment Office; District Environment Committees and Local Environment Committees at different levels. The NES makes some provisions related to mitigating the impacts of climate change. For example, it establishes environmental standards; makes Environmental Impact Assessments (EIAs) compulsory for projects with large impacts on the environment; and authorizes NEMA to institute guidelines or measures for the sustainable use of vital resources such as forests, wetlands, riverbanks, lakeshores and hilly/mountainous areas.

The statute/act also suggests ways of promoting reforestation and the use of renewable energy in Uganda. Nonetheless, the statute does not make specific provisions related gender. Gender is only mentioned in the first schedule in reference to the composition of the Policy Committee on Environment, in which the Minister responsible for Gender and Community Development is one of the eleven members. Climate is just mentioned under the definitions of the terms 'element' and 'environment', where climate is recognized as a constituent part of the environment. Such omissions could partly be attributed to the fact that climate change was not a priority concern and hence not given enough focus during the formulation of the act as climate change was not on many policy agendas at that time. NEMA, the environmental body put in place to execute government mandate on environment is expected to prepare and disseminate a state of the environment report once in every two years (this has been achieved). The statute on financial provisions provides for the establishment of the National Environment Fund with financing sources from Government, fees charged, fines levied, gifts, donations, voluntary contributions.

Funding from donors such as from the Global Environmental Fund is being used for research and environmental awareness documentaries (such as ECO-TALK).

2.3.1.3 The National Forestry and Tree Planting Act, 2003

The purpose of the act is to create an integrated forestry sector that will facilitate the achievement of sustainable increase in economic, social and environmental benefits. The act is intended to guide and cause the people of Uganda to plant trees; ensure forests and trees are conserved to meet the needs of the present without compromising the rights of the future generations; promote the improvement of livelihoods through poverty eradication; encourage public participation in management and conservation of forests and trees; and facilitate greater public awareness of cultural, economic and social benefits of conserving and increasing sustainable forest cover among others.

The act calls for conservation of natural resources, especially soils, air, and water quality; and conservation of natural heritage and promotion of aesthetic, cultural and spiritual values. It prohibits cutting, disturbing, damaging, burning or destroying any forest produce or removing or receiving any forest produce except under lawful regulations. Other prohibited activities include grazing, camping, livestock farming, planting or cultivation of crops, recreational, commercial, residential, industrial or hunting in reserved forests. This is an attempt to preserve forests for sustainable utilization.

Although the act provides for sustainable forest management that have an effect on weather changes; it makes no mention of explicit focus on forestry as an adaptation strategy to climate changes. In addition, the act remains generic on gender issues, paying no specific attention to different roles/functions that men and women have in forests management. It makes no attempt to map out men and women's varying levels of vulnerability to reduction in forest cover.

2.3.1.4 The National Environment Regulations Statutory Instrument 153 – 6.

The National Environment (Mountainous and Hilly Areas Management) regulations spell out how mountains and hilly areas shall be managed. The legislation gives powers to the district environment committee with respect to hilly and mountainous areas in its jurisdiction to: (i) regulate land use through zoning, (ii) restrict and control activities which are inconsistent with good land husbandry practices, and (iii) make guidelines for the management of areas prone to landslides, floods, drought, avalanches, falling rocks, fires and damage by wind

In addition, the statutory instrument highlights restrictions on the use of mountainous and hill areas; the roles of local councils, landowners, occupiers and users and provides rules for soil conservation. It further provides guidelines on how to handle offences penalties and appeals. However, the statutory instrument is gender blind as it does not give guidelines on how issues of gender inequalities and discrimination should be handled.

2.3.1.5 Guidelines for Wetlands Edge Gardening, 2005

The guidelines for wetlands edge gardening advice wetland users to form common land/wet land associations or develop a common land management scheme to secure their rights of access to and use of a wetland or wetland section and its natural resources such as papyrus. The associations would be required to develop wetland resource use management plans and by laws for the land and wetland under control by the association. Although, the guidelines provide good information on wetland use and management, it is short on the dissemination plan which would take into consideration different stakeholders. The guidelines are gender blind. The guidelines do not target the different users (men and women) of the wetlands and does not address gender inequalities in resource distribution and use.

2.3.1.6 Other relevant legislations

Other relevant legislations include: The 1995 Water Statute which provides the coordination mechanism of all public and private activities that might influence the quality distribution, use or management of water resources; and the 1998 Land Act that provides for land ownership and use rights. The Land Act**,** Section 44 provides for the utilization of land. It states that a person who owns or occupies land shall manage and utilize the land in accordance with the Forestry Act, the Mining Act, the National Environment Statute (1995), the Water Statue (1995) and any other law.

2.3.2 Policy review

Uganda has been actively involved in the global process and negotiations for addressing the impact of climate change. The government recognizes the United Nations Framework Convention on Climate Change (UNFCCC) (1992), the Kyoto Protocol and Clean Development Mechanisms among others, global mechanisms that call upon states to address climate change challenges by putting in place interventions that would ensure "*stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*" (UN, 1992).In response to this global call, the government of Uganda developed a National Adaptation Programmes of Action (NAPA) that identifies the urgent and immediate adaptation needs of the country. Consequently, Uganda was selected, among other countries, to benefit from the Global Environment Facility's (GEF) Low Carbon Development Strategy (LCDS) fund to implement the NAPA. The country has actively participated in the Conference of Parties (COP) meetings as part of its commitment towards addressing climate change challenges. Uganda developed a road map to Conference of Parties (COP) 15 (Government of Uganda, 2009a) that highlights the national framework guiding mitigation, adaptation and delivery of services to address the impact of climate in the country.

Although Uganda does not have a working national policy on climate change yet, there are a number of policies and laws that address issues relating to the environment and climate change matters in particular. The current policy frameworks that address these include:

2.3.2.1 The Energy Policy, 2002

The national energy policy for Uganda was passed in 2002. The policy provides for the four energy sectors. The policy is supported by other sub polices, these are the Renewable Energy policy, 2007 (REP) for the renewable sector and the National Oil and Gas Policy, 2008 (NOGP) for the petroleum sector. The 2002 policy was initiated to sustain the economic growth the country had achieved in the last decade and to ensure widespread access to affordable modern energy. The main policy goal is: "to meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner." The policy provides general objectives which differ from its overall policy goal. The policy objectives include: a) Improvement of energy security; b) Reduction of adverse environmental impacts arising from the use of energy; and c) Improvement of industrial competitiveness.

The current institutional framework for the petroleum sector was set up to facilitate the promotion and exploration for oil and gas. The NOGP highlighted the need to enhance this framework to include broader aspects of the industry (upstream and downstream). Two state companies are yet to be created. The Petroleum Authority of Uganda (PAU) for handling regulatory functions and the Uganda National Oil Company (NATOIL) for handling the business/commercial aspect. In 2002, the goal was to establish the petroleum potential of the country and promote exploration. This has been successful and it is now established that the country has commercial reserves of oil.

Some of the major challenges in the implementation of this policy have been finance, political resistance from environmentalists, continual increase in the cost of energy generation, too many government institutions involved in each sector with each having a major role to play (each pushes their own agenda) which has affected coordination leading to bureaucratic and unnecessary delays in decision making and above all poor governance.

2.3.2.2 The Renewable Energy Policy for Uganda, 2007

The policy focuses on making renewable energy a substantial part of the national energy consumption with a goal of increasing the use of modern renewable energy, from the current 4 percent to 61 percent of the total energy consumption by the year 2017. The need for a renewable energy policy was rooted in the recognition of the government's commitment on greenhouse gas emissions reductions, under the Kyoto protocol and to contribute to the global fight against climate change. The policy recognises the need for women to play a special role in the provision and management of energy sources since they are most affected by inadequate energy supplies. It recognises gender differences in interests, needs and priorities in the planning, implementation and monitoring of renewable energy projects. Thus, energy technologies and services will be designed and disseminated in ways that take into consideration the differences in tasks and roles within the household, participation in decision making, and energy needs in situations of energy shortage.

The policy's objectives further emphasize mainstreaming poverty eradication, equitable distribution and gender issues into renewable energy strategies such as provision of improved wood stoves, improved charcoal stoves, institutional stoves, baking ovens, household biogas, solar home systems and fruit driers.

Although the policy identifies gender and poverty as key issues that need to be integrated in renewable energy management, it does not identify the institutional mechanism for integrating gender. The policy neither recognises the role of the Ministry of Gender, Labour and Social Development (MoGLSD) as the national institution mandated to support all public and private institutions to mainstream gender in their operations, nor identifies a focal point unit for ensuring that gender is an integral part of renewable energy interventions in the country. Though the policy addresses environmental concerns (through making environmental assessment reports), the Renewable Energy Policy currently is not being implemented. Similar to the petroleum sector, the institutional framework is inadequate. There is yet to be the creation of a Renewable Energy Department and an Energy Conservation Department in the Ministry of Energy and Mineral Development.

2.3.2.3 The Uganda Land Policy, 2011

The National Land Policy (NLP) vision, goal, objectives and principles, aim for sustainable management of land and its resources. The policy tackles the most emotive, culturally sensitive, politically volatile and economically central issue in Uganda, land, which is a political issue. The environmental resources it contains and harness make land a highly contentious issue. The policy notes that due to limited budget allocations, Government is yet to buy out the bigger part of the Mailo land that is being mismanaged with natural resources on them. This has led to depletion of their resources or landlessness. Privatisation of communal grazing lands and other pastoral resources has forced some pastoral communities and ethnic minorities to invade other people's land or to encroach on protected areas, in their neighbourhood. These have repercussions on environment, encroachment on wetlands, Protected Areas (PAs) etc. Elements of political interference have severely hindered progress in public delivery of land services, making it slow, cumbersome, frustrating and too costly to the public.

The policy recognises gender divisions in land ownership and use but implementation and enforcement mechanisms are still lacking. Despite the policy making attempts to harmonise aspects related to regulation of land use as regards standards and guidelines for sustainable management of land resources, it is incapable, by its nature, of dealing with tenure issues that make, its implementation cumbersome. The Land Act (cap 227) and the constitution of the republic of Uganda do not take into account the role of local communities in the preservation and management of common property resources. With regard to natural resources and environmental management, users of land on which natural resources are situated, are not aware of the sustainable use practices, existing legal frameworks and mechanisms of restoration of degraded environment. The NLP covers issues related to climate change but the policy does not suggest the nature of adaptation strategies to be designed and how they will be executed.

2.3.2.4 The Uganda Forest Policy, 2001

The goal of the Uganda Forest Policy (UFP) is to have “an integrated forest sector that achieves sustainable increases in the economic, social and environmental benefits from forests and tress by all the people of Uganda, especially the poor and vulnerable”. Two higher level statements establish the policy i.e. forestry on government land and forestry on private land. Additional important statements that we point out are those that address conservation of forest biodiversity, on watershed management and soil conservation and supply of trees seeds and planting stock (currently being undertaken). The UFP notes an increasing concern about the deteriorating state of forestry in the country. It acknowledges that the natural forest cover is receding; ecological services are declining; and that there is increasing pressure on forest land and increasing demand on forest products. It further indicates that management capacity is limited and institutional weaknesses constrain development of the forest sector. Nonetheless, direct climate concerns, in maintaining and managing forests, from degradation, are not clearly brought upfront.

The policy recognises gender differences in forest resource utilisation whereby men are typically more interested in trees as sources of construction materials or cash income, while women's interests are more in the supply of firewood and food production. It acknowledges women’s disadvantaged position relating to security of tenure, where in many cases they cannot inherit land and are rarely involved in decision-making over natural resource management or the management of household income. All these factors are disincentives for women to invest in tree planting. In this regard, the policy identifies gender and equity as key element in the forestry sector and commits the government to ensure that women, youth and poor people are beneficiaries in the development of the sector. While the policy recognises gender and equity as important in the forestry sector, it is not clear on addressing climate change issues, and how men and women can adapt to changes in the weather.

2.3.2.5 National Policy for the Conservation and Management of Wetland Resources, 2009

The overall aim of the Conservation and Management of Wetland Resources policy is to promote the conservation of Uganda's wetlands in order to sustain their ecological and socio-economic functions for the present and future well-being of the people. The policy provides for environmentally sound management of wetlands as means to conserve the wetland. The policy promotes useful ways of using wastelands to minimize on their destruction and maintain their functions of cushioning communities against climate change. Wetlands have different functions for men and women but these are never highlighted in the policy. The policy refers to the functions of wetlands in generic terms -all people of Uganda-yet different activities for men and/or women endanger wastelands. Likewise men and women have different patterns of access to and control over wetland resources as well as access to information necessary for preservation of wetlands. No provisions are made in integrating issues of climate change and gender in wetland management.

2.3.2.6 The National Policy for Disaster Preparedness and Management, 2010

The people of Uganda, through the Constituent Assembly in Objective 23 and Article 249 of the resulting Constitution, called for an end to intolerable and persistent loss of life, suffering and disruption of economic activities by disasters resulting from the lack of preparedness and patchy uncoordinated responses. Thus, they came up with the National Policy on Disaster Preparedness and Management whose overall policy goal is to promote national vulnerability assessment, risk mitigation, disaster prevention, preparedness, effective response and recovery in a manner that integrates disaster risk management with development planning and programming. The policy highlights two types of disasters: Natural hazards (drought, floods, famine/food security, landslides and mudslides, epidemics, human epidemics, crop and animal epidemics, pandemics, heavy storms, pest infestation and earthquakes) and human induced disasters (of interest, environmental degradation among others). It acknowledges the need for public awareness, limited capacity, need for vulnerability analysis. Climate change is mentioned as a major problem with need for government to develop adaptation and mitigation measure through increasing research on the subject matter. In addition, the policy notes the importance of gender integration in its implementation. But other than recognising gender and climate change, the policy does not spell out how gender will be mainstreamed in enforcing of core activities and even more specifically how government should handle the aspects of climate change in its planning agenda.

2.3.2.7 The Mineral Policy of Uganda, 2002

The policy vision for mining intends to attract investment, build capacity for acquisition and utilisation of Geo-data and increase mineral production for economic and social development of Uganda. Two of the major objectives of the mineral policy are (1) to minimise and mitigate the adverse social and environmental impacts of mineral exploration; and (2) to remove restrictive practices on women participation in the mineral sector and protect children against mining hazards. Specifically, in an effort to minimise and mitigate the adverse social and environmental impacts of mineral exploration, Government shall ensure compliance with the existing laws and regulations on environment, human health and safety. This is achieved by: (a) strengthening the environment monitoring unit of the lead agency; (b) carrying out sensitisation of the society; (c) encouraging the application of environmentally friendly technologies in mineral exploitation; (d) drawing up and establishing health and safety regulations; (e) formulating preventive measures against accidents, and human health and safety hazards; and (f) promoting affirmative action in favour of women and prohibiting child labour in mining.

The major issue the policy stresses is creating a good policy environment to attract private (both local and foreign) investment with environmental concerns being addressed only at the phase of project implementation. Here the policy indicate NEMA as responsible for approving environmental impact assessments and reports for mining projects, in co-ordination with mineral agencies. The Mining Act last revised in 1964 does not address environment, gender and labour contentions. The constitution in objective XIII talks about the protection of natural resources with minerals and oil mentioned. Article 244 indicates that parliament shall make laws regulating (a) the exploitation of minerals: (b) sharing of royalties arising from mineral exploration and (e) minerals and mineral ores shall be exploited taking into account the interest of the individual land owners, local governments and the Government. Many of the objectives are to be implemented as short term arrangements (0-2 years) and others such as formulation of women mining groups as medium term arrangements (3-5 years). Despite the policy clearly articulating that interest of individual land owners will be taken care of, this only exists on paper. Government retains information if new minerals are discovered by first buying land from owners who do not know their true land value and then highly placed government individuals reap the benefits. Environmental concerns are secondary in cases where financial gains are much higher.

2.3.2.8 The Uganda Gender Policy, 2007

The goal of the Uganda Gender Policy is to "achieve gender equality and women's empowerment as an integral part of Uganda's socio-economic development". The purpose of this is to establish a clear framework for identification, implementation and coordination of interventions designed to achieve gender equality, women's empowerment and monitoring and evaluation of programmes with a gender perspective.

The National Gender Policy (NGP) was first approved in 1997. It was then revised in 2007 highlighting its major achievements, challenges and need for revision. The 2007 policy revisions were designed to guide and direct all levels of planning, resource allocation and implementation of development programmes, with a gender perspective. With priority areas of focus being: improved livelihoods, promotion and protection of rights, participation in decision-making and governance, recognition and promotion of gender in macro-economic management.

The constitution of Uganda highlights gender in its objectives sections VI and XV. The Uganda NGP conforms to regional and global obligations on gender equality and women's empowerment. The success of the NGP can be seen with the recognition of women's land rights in the Land Act (cap 227) and Land Acquisition Act (cap 226) and spousal consent is a requirement on all matters relating to land which the family derives substance. Despite the existence of the NGP, there are significant inequalities that still do exist with regard to rights to property. Apart from a few, economically advantaged, the majority of women have only user rights determined by the nature of relationship they have with a male land owner-father, husband or brother. Implementing the NGP is multi-sectoral such that due to its cross cutting nature, different actors/sectors are responsible for financing the gender mainstreaming interventions pertinent to the respective sector. Thus, despite many sectors including gender action plans in their policies, many are not falling through with actions and enforcements. Some include gender to solicit financial support from donors and government and also to safe guard themselves against gender activists.

2.3.3 Action plan documents

2.3.3.1 National Development Plan 2010/11 – 2014/15, 2010

The National Development Plan (NDP) (2010/11 – 2014/15) is Uganda's overall national framework that guides planning for all development sectors in the country. The NDP highlights the constraints to the performance of climate change interventions. The plan acknowledges the constraints to the performance of the agricultural sector, including, (1) Traditional and cultural attitudes: many producers have been in peasantry production for a long time and are used to certain old practices which have become a tradition. For example; the use of a hand hoe, subsistence production, dominance of women in production and men in marketing, imbalances in land ownership between men and women, and marketing imbalances in land ownership between men and women. (2) Land tenure and access to farmland: Uganda's divergent system of land tenure and overlapping land rights have impacted negatively on long-term investments in agriculture. Furthermore, many landless potential farmers (especially women) cannot easily access land because of costs, cultural norms and the increasing population is gradually worsening the problem of land fragmentation and in so doing, negating efforts to transform agriculture from subsistence to commercial production.

The plan identifies strategies and interventions to address the effects of climate change. It makes a number of environmentally friendly proposals intended to promote sustainable development such as increasing electrification coverage to 20 percent and reducing power losses. The plan also proposes increasing access to water for production – irrigation from 14,418 ha to 22,00 ha, increasing water supply for livestock watering in the cattle corridor from the current 36 percent to 50 percent and those from outside the cattle corridor from 21 percent to 30 percent. The plan further proposes increasing investment in agricultural inputs and water for production to stimulate agricultural productivity, overhauling and automation of the meteorological instrumentation to enhance the predictability of the weather and climate parameters and to increase the reliability of the forecasts. The NDP provides implementation strategies one of which focuses on gender, calling for the development of "…an action plan promoting gender equality and transforming mind-set attitudes, cultural practices and perceptions that show socioeconomic growth and structural transformation in relation to climate change adaptation".

While the NDP situational analysis identifies gender issues and acknowledges gender inequality as a binding constraint in Uganda's development, the section that addresses climate change is gender blind. This is a serious omission because in order for gender to be integrated in the sector policies, it should be mainstreamed in the NDP.

2.3.3.2 Uganda National Adaptation Programmes of Action, 2007

The National Adaptation Programmes of Action (NAPA) is Uganda's first action plan addressing the effects of climate change in the country (Ministry of Water and Environment, 2007b). Uganda's NAPA was developed through participatory approach that gave communities an opportunity to contribute their views on climate variability and climate change and identify coping mechanisms. The NAPA document was based on the country's obligation to achieve the Millennium Development Goals and the objectives of the Poverty Eradication Action Plan (PEAP) – the country's development framework at that time.

NAPA recognises communities' concerns related to how climate change has rendered indigenous knowledge irrelevant and the communities coping mechanisms less effective. NAPA suggests that selection of project areas should focus on community tree growing in the highland areas, which are prone to landslides and adaptation to drought in the semi-arid areas. The NAPA identifies a number of challenges including inadequate understanding of climate change and its impacts; inadequate technical capacity, inadequate financial resources; and weak institutional and coordinating mechanisms.

The document recognises the different effects of climate change on men, women and the youth; and how women play a key role in caring for households. It recognises the need for special emphasis on vulnerable communities and gender dimensions. While the justification of some projects (projects 6 and 7) is based on the gendered effects of climate change, it does not propose strategies to address gender inequalities.

2.3.3.3 Plan for Modernization of Agriculture

The agricultural sector has been noted as the most vulnerable to the effects of climate change and yet, it's the backbone of Uganda's economy. Through the Plan for Modernization of Agriculture (PMA), Uganda hopes to eradicate poverty through profitable competitive and dynamic agricultural and agro-industrial sector. However, if this vision is to be realized, sustainable climate change adaptation measures should be integrated in strategies for improving the livelihoods of both men and women. The objective of PMA alludes to this: "…increase incomes and improve the quality of life of poor subsistence farmers, improve household food, security, provide gainful employment and promote sustainable use and management of natural resources."

In this regard, the PMA provides for sustainable management and use of the natural resources for the following vulnerable groups: women who have limited economic opportunities due to their role in society and their relationship with men, widows and female-headed households have limited access to resources, male youth lack opportunities for financial gain and consequently, social well-being, households with large families-many dependants place a strain on meagre household resources, people dependent on a relatively vulnerable source of income. This group includes fishermen, nomads and small-scale farmer who rely on growing one low- value crop for sale. Causal labourers rely on limited and seasonal work and others, orphans and neglected children, the disabled, socially isolated, the sick and others.

The PMA emphasises the importance of focussing on the different categories of the poor including the destitute - people who do not have hope, and who have no assets. It recognises the need to identify and address emerging environmental issues and opportunities. While the PMA recognises the need for addressing emerging environmental issues, it does not specify strategies/interventions on how to address gender concerns in the environmental sector.

2.4 Conclusion

This chapter discussed an overview of the Ugandan economy, climate definitions and drivers in the Ugandan context and lastly, reviewed relevant legislation and polices in relation to climate change, gender and welfare. Analysis of the economic status reveals that, agriculture is still the main economic activity of the people in Uganda despite agriculture’s recent low contribution to GDP. Noted are the frequent occurrence of climate distress events in Uganda based on our understanding of the changes in SSTs and climate definitions. Policy analysis reveals that while Uganda has developed good policies, legislations and measures that are meant to address the environment in general and effects of climate change in particular- mitigation and adaptation with inclusion of gender implications are inadequate. Nonetheless, polices reviewed are either gender neutral or gender blind. In addition, policies lack a clear dissemination strategy, an indication that the majority of policies and legislations remain on paper and implementation is still limited. Put differently, there is no clear indication that the policies are being enforced. With climate change being a global issue, monitoring and evaluation of policies in addressing this concern is important.

CHAPTER THREE

ANALYSIS OFCLIMATE VARIABILITY AND CHANGE IN UGANDA

3.1 Introduction

The objective of this chapter is to empirically analyse Uganda's climate and how it has been changing over time. Examination of climate trends is mainly driven by the increasing need to understand the key indicators of climate variability and change given that Uganda's economy is highly rural. Many Ugandans are involved in agricultural practices, an activity which depends on nature and hence, affected by changes in temperature and rainfall. Implying that, the agricultural climate related shocks and response mechanisms recoded in survey datasets at the household level covering two agricultural seasons adequately capture discrepancies in Uganda's changing climate. Therefore, this creates a need to first understand the key indicators of climate change as this directly affects agricultural production, income, welfare and livelihoods of Ugandans.

In this regard, the key research question that is guiding this chapter is 'to what extent has Uganda's climate altered?' To answer this, we specifically need to build on our earlier understanding of climate drivers in Uganda covered in Chapter 2. In here, we analyse quantitatively climate change indicators, make comparisons between earlier years and to date then calculate anomalies perceived. This form of analysis establishes the relationship between climate shocks, variability and change. This chapter contributes to the on-going climate change debate where countries, households, and the population are being encouraged to watch out for climate extremes and to get equipped in climate change analysis. Understanding the degree of climate change enables all stake holders to deduce long-term rather than short-term adaptation strategies.

The rest of the chapter is organised as follows: Section 3.2 presents a review of literature on climate variability and change. Discussed in Section 3.3 is the methodology employed; Section 3.4 discusses the data used for analysis, while Section 3.5 presents the results and discussion. Section 3.6 concludes the chapter.

3.2 Related literature on climate variability and change

Literature on the determinants of natural climate variability and change exists (L'Heureaux et al., 2002; Folland et al., 2002; Salinger, 2005). Throughout historical time, and agrarian settlement, climate has varied. Both natural climate change and variability has occurred, in which, past and current agricultural and forestry systems have adapted to (Salinger, 2005). The record of observed climate, by instruments and proxy indicators, suggest that the rate and magnitude of change and variability has been quite modest, with centennial temperature changes globally in the order 0.5^0C, and locally 1^0C. Natural variability of the El Niño Southern Oscillation (ENSO) has been a factor in analysis of climate variability and change throughout recorded history. However, the magnitude and rates of change that are projected for the 21st century fall outside that range. The 90 percent confidence range of global warming is in the range of 2-4.5^{0}C (Wigley and Raper, 2001).

Salinger, (2005) identifies the underlying trends in climate change and variability in the twenty first century. He indicated that the key trends in climate during the 21st century were: (i) the continued rapid temperature increase in high latitudes of the Northern Hemisphere; (ii) further drying in Mediterranean areas, and some tropical and sub-tropical latitudes; and (iii) the accentuation of increasing climate variability especially in sub-tropical and tropical latitudes. Thus, temperature increases or decreases outside the range (the most rapid change being 1^{0}C per century) creates unstable climate, as parts attempt to adjust to rapidly changing temperatures (Salinger, 2005). L'Heureaux et al. (2002) support this argument as they assert that the interplay between the ocean and the atmosphere is most pronounced in the global tropics due to the first order approximation between warm SSTs and the enhancement of deep convection. In this regard, authors argue that climate, agriculture and forestry are linked. That is, if native forests take centuries to adjust their range, then agriculture will face an almost impossible adjustment. Salinger (2005) then concludes that such a situation is creating a potentially dangerous climate where the stability of agriculture and forestry systems is threatened. Meaning that, climate surprises for example flooding from unmanageable catchments and inundation of land areas due to storm surges and sea level rise hinder agricultural activities. As a result, adaptation strategies are going to be of crucial importance ranging from traditional to new technologies.

In related developments, USGS (2007) report points out that climate influences every aspect of life on earth, affecting human health and well-being, water and energy resources, agriculture through crop failure, forests and natural landscapes, air quality and sea levels. According to IPCC (2007), evidence shows that global warming due to human activities since 1750 is unequivocal. In addition to increases in global average air and ocean temperatures, observations made find widespread melting of snow and ice, rising sea levels, widespread changes in precipitation amounts, ocean salinity, and wind patterns; and increasing occurrences of extreme weather including droughts, heavy precipitation, heat waves and intensity of tropical cyclones.

For example, Folland et al. (2002), in their work address seven questions on how to detect climate change. That is: How much is the world warming? Is the recent warming unusual? How rapidly did climate change occur in the distant past? Have precipitation and atmospheric moisture changed? Has climate variability, or have climate extremes, changed? Are the observed trends internally consistent? And are the atmospheric/oceanic circulations changing? The authors' analysis supports the arguments made by L'Heureaux *et* al. (2002). Their argument is that in the late twentieth-century, behaviour ENSO is related to variations in precipitation and temperature over much of the global tropics and subtropics and some mid-latitude areas. In addition, they show that the resent warming is unusual because the magnitude of Northern Hemisphere warming over the twentieth century is likely to have been the largest of any century in the last 1000 years. They further note that regions with increases in total precipitation are having more pronounced increases in extreme daily to multi-daily precipitation events. The converse is also true for regions with less pronounced precipitation events. Over the latter half of the twentieth century, it is likely that there has been a 2-4 percent increase in the frequency of heavy precipitation events reported by the available observing stations in the mid-latitudes and high latitudes of the northern Hemisphere (IPCC, 2007).

In many regions, inter-daily temperature variability has decreased with significant reduction in the frequency of extreme low monthly mean and seasonal average temperature across the globe (Folland et al., 2002). It is noted that the observed trends are internally consistent, where temperatures over the global land and oceans have increased over the twentieth century. Evidence alludes to exceptional warmth of the late twentieth century relative to the last 1000 years with 1998 being the warmest. Folland et al. (2002) conclude that the variations and trends of the examined indicators (temperature, precipitation) consistently and very strongly support an increasing global surface temperature over at least the last century, although substantial shorter-term global and regional deviations from this warming trend are very likely to have occurred.

Other authors, particularly Levitus et al. (2000b) support Folland et al. (2002)'s findings that increasing number of accessible sub-surface ocean temperature data shows that the global ocean heat content has increased since the late 1950s. This increase is superimposed on substantial global decadal variability. More than half the heating is contained in the uppermost 300m where it is equivalent to an average temperature increase of 0.037^0C per decade.

Using the 250km analysis to illustrate seasonal mean climate variability on regional special scales and further investigating the significance of recent extreme events around the globe using summer temperature anomalies, Hansen et al. (2011) find that most regions are warmer in recent years than during 1951-1980even though the United States, was unusually cool in 2004 and 2009. Using the standard deviation of local surface temperature during 1951-1980 methods, a measure of the typical magnitude of year-to-year variations of seasonal mean surface temperature during a 30 year base period Hansen et al. (2011) find that inter-annual variability of surface temperature was larger in the winter hemisphere than in the summer and larger over land than over the ocean. The underlying reason for the large winter variability is the huge difference in temperature between low latitude and high latitudes in winter.

Furthermore, Hansen et al. (2011) argues that seasonal-mean temperature probability has shifted dramatically over the past three decades where the probability of distribution has shifted towards higher temperatures by more than one standard deviation. In addition, there is a broadening of the distribution of a larger shift at higher temperatures than at low temperatures. They note that there are more occurrences of extreme weather events such that the ‘climate dice’ is now loaded to the degree that the perspective person (old enough to remember the climate of 1951-1980) can recognize the existence of climate change.

A group of researchers suggest that the high summer temperatures and drought in the United States in the 1930s was due to changes in the SST patterns plus natural variability (Nigam et al., 201; Hoerling et al., 2011). However, others present evidence that agricultural changes and crop failure contribute to changes in surface albedo, aerosol (dust) production, high temperatures and drying conditions (Cook et al., 2009; 2010; 2011).

Furthermore, there is empirical evidence supported by climate simulations (Puma and Cook, 2010; Cook et al., 2011), that agricultural irrigation has a significant regional cooling effect. In addition, increasing amounts of irrigation over the second half of the 20th century probably contributed a summer cooling tendency in the United States that partially offset greenhouse warming. Such regionally varying effects could be partially responsible for differences between observed global change and observed change in specific regions. It is documented that climate models may not be capable of simulating changes for specific regions as yet but one important regional effect that may be robust is expected pole-ward expansion of climate zones as the world warms. Theory and climate models indicate that subtropical regions will expand pole-ward with regional global warming (Held and Soden, 2006; IPCC, 2007).

On the other hand, Archer (2012) postulates that the warmth experienced now is not only due to the rise in global temperature alone. But like other researchers on climate change, he emphasizes that the changing average temperature of the Earth will alter climate, rearranging weather patterns and water supply in ways that are not easy to forecast reliably and so not easy to prepare for. He further points out that international responses to climate change have largely focused on mitigation measures that aim to reduce greenhouse gases and enhance carbon sinks[7] and less on adaptation. In recent years, many researchers such as Archer (2012) and Soussain et al. (2003), recognise adaptation strategies as critical elements in reducing the vulnerabilities to climate-induced change to protect and enhance the livelihoods of poor women and men.

In summary, research on climate variability and change discussed in this section clearly shows that many studies have been carried out outside Africa. Others that have included Africa refer only to the Mediterranean region and general tropics and subtropics. All the studies use anomalies in analysis of trends in temperatures and precipitation as a tool for evaluating global climate variability and change. Of emphasis is the inclusion of global warming, brought about by human activities, as the lead cause of climate change. Authors try to distinguish between natural climate variability and climate change that is induced by human activities, though many find it difficult to separate data in their analysis. Thus, literature stipulates the use of standardising climate indicators over 30 year periods and use of mean temperature and precipitation to analyse climate change.

[7]Carbon sinks are the natural ability of trees, other plants and the soil to soak up carbon dioxide and temporality store the carbon in wood, roots, leaves and the soil.

This study takes a similar approach and employs the same methodology as Salinger, (2005) and Hansen *et* al, (2011) to analyse climate variability and change for Uganda. Thus, the study adds to the limited literature on climate change analysis in Africa and in particular, Uganda.

3.3 Methodology

As suggested in climate change literature (IPCC, 2001; 2007), we use a 30 year base record (1961-1990) as the Long Term Mean (LTM) for monthly rainfall totals. The LTM is calculated for each weather station to generate onset and cessation of rainfall anomalies for the 1980-2011 period. The anomalies for onset and cessation of rainfall are derived by subtracting the LTM from the corresponding actual year period rainfall for each weather station.

As Hansen et al. (2011), we calculate annual rainfall and temperature anomalies by standardising data for 1980-2009 data series (a 30 years base period) to derive anomalies for the entire data series in this study for each weather station with complete data series. More succinctly, each weather station time series annual average temperatures (maximum and minimum) and rainfall trends are converted to anomalies relative to the 1980-2009 standardized value. Anomalies for annual maximum and minimum mean temperatures range are expressed in absolute units (i.e., degrees Celsius (°C)). Weather stations with data series of less than 30 years from 1980–2011 are excluded from the analysis[8]. Graphical analysis is used to present results. For emphasis, no climate change simulations and predictions are undertaken in this chapter due to limited availability of climate variables, capacity and forecasting packages for climate models. Thus, generating climate predictions would have been informative; however, it is beyond the scope of this study.

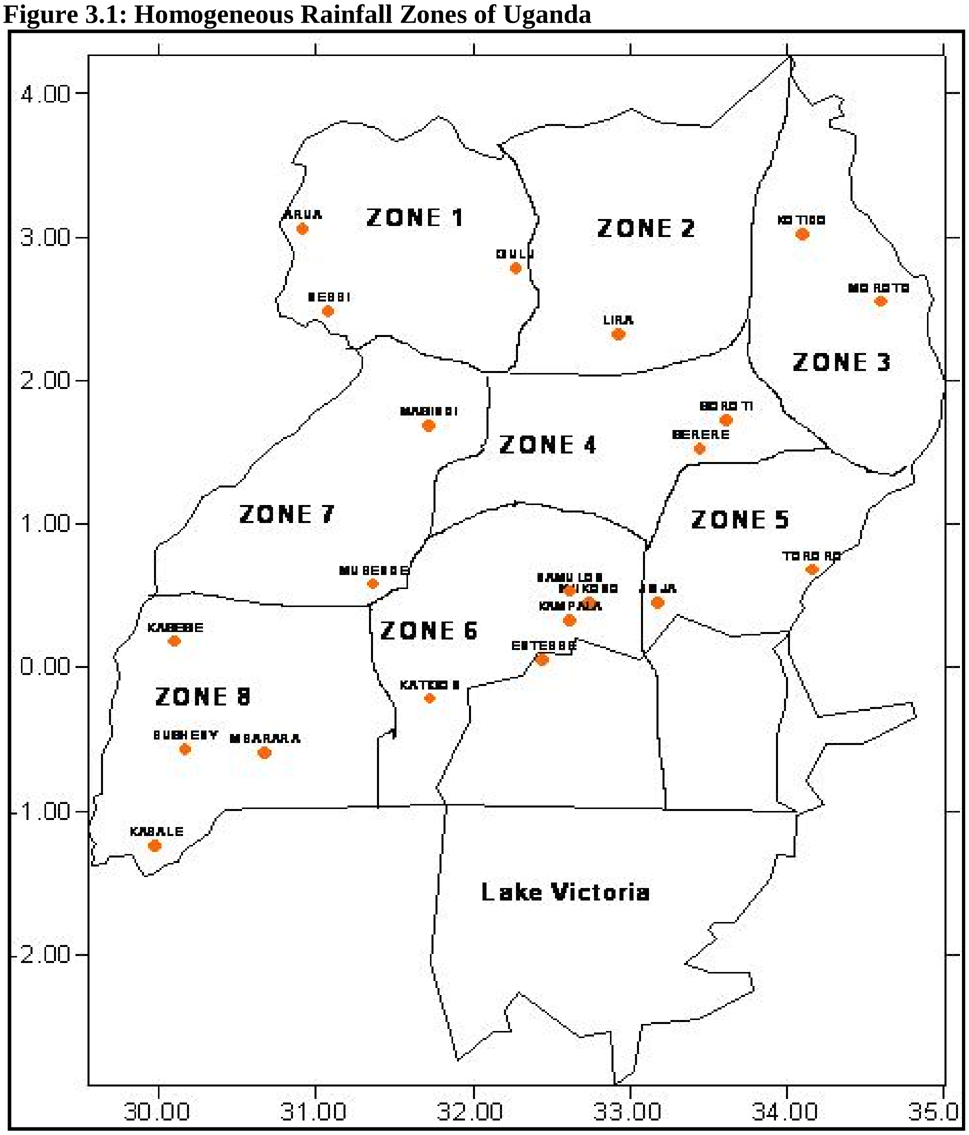
3.4 Data sources and transformation

We utilise data from the Uganda Department of Meteorological (UDoM) under the Ministry of Water and Environment (MoWE) spanning over a period of 32 years (1980-2011). The data is obtained from synoptic stations across the country. Uganda had been delineated into homogenous climate zones (Figure 3.1). That is, zones 1, 2, 4, 5, 6, 7 and 8 receive bimodal rainfall while zone 3 receives single season (uni-modal) long rains. Nonetheless, rainfall densities and number of rainy days in bimodal areas differ. This has an impact on the major forms of farming activities agricultural households engage in. The same holds for temperatures. Zone8 and the mountainous areas in zone 5 can be very cold in the rainy season given their topography. For this study, we gathered data on 13 weather stations (Makerere-Kampala, Entebbe, Soroti, Namulonge, Kasese, Lira, Gulu, Kabale, Mbarara, Masindi, Arua, Kitgum and Jinja) representative of climate zones across the country (Figure 3.1). Throughout this chapter, trends in rainfall monthly totals (mm), relative mean monthly minimum and maximum temperatures (^{0}c) are used in the analysis. The LTM annual rainfall totals per month for each weather station are

[8]Analysis of climate change requires continuous data of no less than 30 years

used to substantiate any anomalies arising during onset and cessation of rainfall, hence covering the two cropping seasons.

Figure 3.1: Homogeneous Rainfall Zones of Uganda



Source: Department of Meteorology, Ministry of Water and environment, 2011

Not all weather stations have complete temperature data but all stations have complete existing rainfall data. According to the UDoM, the breakdown of thermometers in some weather stations take long to be replaced resulting in data gaps. Availability of data for relative humidity is the same as that for temperature as both variables are recorded using the same instruments. Recoding of rainfall and temperature is done on a daily basis at each weather station. Indicators are then aggregated as monthly rainfall totals (mm) and average monthly maximum and minimum temperature or monthly relative means.

Table 3.1 provides descriptive statistics by weather station for both rainfall and temperatures. From Table 3.1, Kasese weather station recorded the least amount of average rainfall over the 32 year period of 863.2mm and Entebbe weather station recorded the highest average rainfall of about 1647.8mm over the same period. Generally, areas around the Lake Victoria basin receive on average high rainfall compared to any other region (Entebbe, Kampala and Jinja). With regard to temperatures, the highest maximum temperatures are recorded at Kasese weather station. Kasese's high temperatures are worrying as Mt Ruwenzori a snow-capped mountain and the second highest in Africa is located in Kasese town. Climatologists have noted the rapidly melting snow at its cape. Kabale weather station has the lowest temperature records for the period under review at 11^0C.This is expected as Kabale has always been the coldest part of the country. Nonetheless, temperature in Kabale three decades earlier where a lot cooler going below 4^0C in some months than what is currently being recorded (UDoM, 2010).

Table 3.1: Descriptive statistics for annual rainfall and temperatures: 1980-2011

Weather Station	Obs.	Mean	Std. Dev	Min	Max
	Annual rainfall totals (mm)				
Kampala	32	1309.27	233.41	782.9	1713.4
Soroti	32	1362.35	230.17	895.3	1787.8
Gulu	32	1467.78	176.00	1159.9	1807.8
Kasese	32	863.22	132.31	642.8	1157.9
Mbarara	32	943.60	163.77	635.7	1274.3
Entebbe	32	1647.84	362.59	1117.1	2679.2
Namulonge	32	1160.86	206.68	729.4	1745.6
Lira	32	1452.30	178.74	1142.1	1780.3
Kabale	32	1018.37	108.44	854.1	1221.6
Masindi	32	1350.08	181.52	1014.6	1768.2
Arua	32	1420.40	128.82	1050.9	1627.4
Kitgum	32	1238.12	327.48	532.7	2243.2
Jinja	32	1314.98	192.80	914.2	1665.6
	Maximum Temperature (^{0}C)				
Soroti	32	29.94	1.11	26.7	31.0
Namulonge	32	28.35	0.44	27.3	29.4
Kasese	32	30.26	0.65	29.3	31.3
Gulu	32	29.67	0.88	28.6	31.4
Kabale	32	24.17	0.43	23.6	25.4
Mbarara	32	27.21	0.84	25.9	31.1
Jinja	32	28.27	0.22	27.6	28.7
	Minimum Temperature (^{0}C)				
Entebbe	32	18.13	0.60	16.3	19.0
Soroti	32	18.43	0.44	17.8	19.4
Namulonge	32	15.94	0.33	15.3	16.7
Kasese	32	17.55	0.79	16.3	18.8
Gulu	32	17.96	0.99	16.8	19.6
Kabale	32	11.25	0.69	9.8	12.3
Mbarara	32	14.96	0.78	13.4	16.4
Masindi	32	17.49	0.72	16.2	18.6
Jinja	32	16.82	0.51	15.7	17.5

Source: Author's own based on data from UDoM, MoWE, 2012

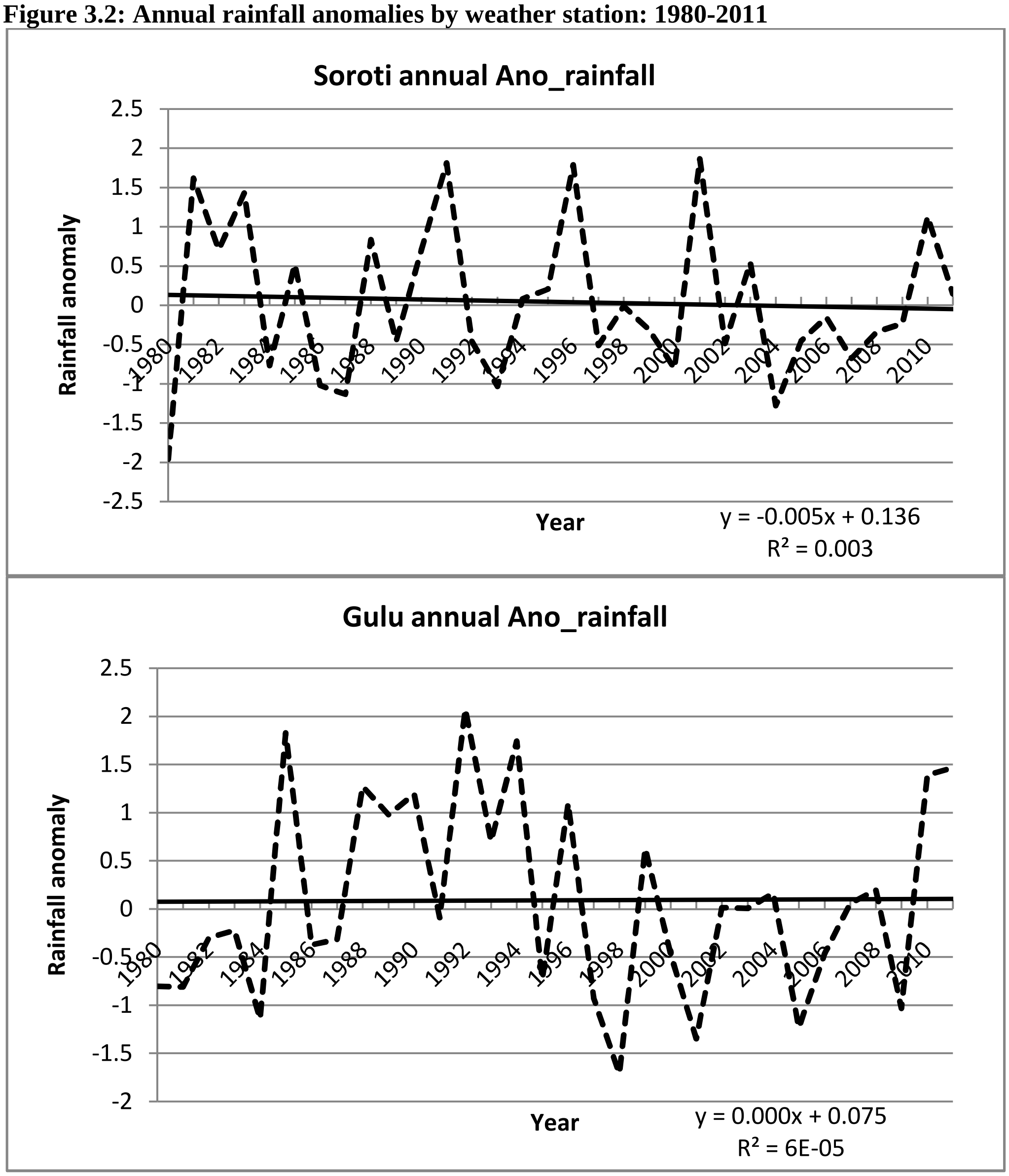
3.5 Results and discussion

As pointed out in Chapter 2, most of Uganda's rainfall and temperature are determined by the conditions in the sea i.e. SSTs with limited influence from other secondary sources such as lakes, rivers, forests, swamps found within the country. Nonetheless, secondary sources too have a major role they play in stabilising/regulating rainfall and temperatures received despite not being the primary determinants of climate. Analysis of climate variability and change necessitates comparisons to be made between actual period records and Long Term Means. In addition, we also observe the patterns in anomalies. In that respect, anomalies that lie out of ±0.5 bounds indicate climate change, those that lie within the ±0.5 indicate climate variability and if anomalies lie on the 0 (zero) line it indicates climate neutrality. Thus, throughout, we discuss climate change using the three main indicators pointed out in literature (Folland et al., 2002; Salinger, 2005 and Hansen et al., 2011). These are: rainfall, temperatures, onset and cessation of rainfall patterns.

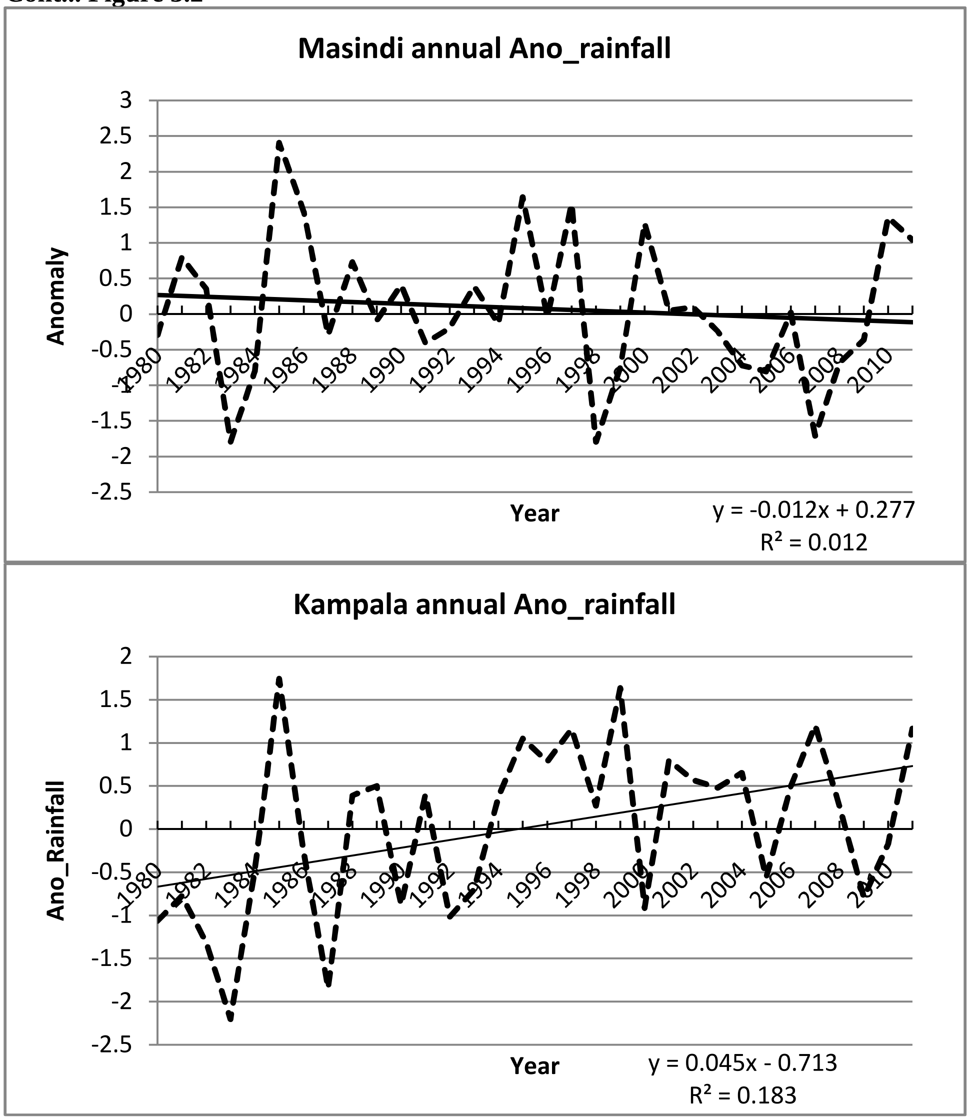
(i) Trends in rainfall patterns

In using annual average rainfall for each weather station, this enables us to depict climate variability and change of rainfall patterns across the country as represented by the homogenous climate zones in which a specific weather station is situated. Figure 3.2 and Appendix A-Figure A.1 present annual rainfall anomalies by weather station. A linear trend is added to indicate the direction of rainfall over time. Specifically, we interpret rainfall anomalies in such a way that whenever the gradient is positive this implies an increase, negative gradient implies a decrease and a zero gradient implies no change in rainfall patterns over time.

Figure 3.2: Annual rainfall anomalies by weather station: 1980-2011



Cont... Figure 3.2



Source: Authors own based on data from UDoM, MoWE, 2012

From Figure 3.2 and Appendix A-Figure A.1, we note that rainfall anomalies are persistent over time and differ by weather station. Consequently, we observe that most of rainfall patterns lay outside the ±0.5 bands. As Folland et al. (2002) argue this is an indication of climate change that is affecting natural rainfall patterns over time in Uganda. Findings reveal that Gulu and Masindi weather stations receive on average relatively high rainfall and linear trends for each station's annual anomalies are in support of the descriptive statistics. Nonetheless, closer observations show that despite the positive annual anomalies trend in rainfall density recorded at the Gulu weather station (located in zone 2), rainfall annual average totals (mm) have actually declined compared to the past decades.

On the other hand, results for Masindi weather station indicate a negative rainfall anomaly trend. This essentially implies rainfall received has substantially declined. These findings support arguments made in the IPCC (2001; 2007) reports; where they assert that climate change leads to an increase in rainfall received in some regions located in the tropics especially in months when rains are expected though generally rainy days have declined.

Comparing results from Figure 3.2 with the ONI (in Chapter 2-Table 2.2), in the years 1980, 1982-84, 1985/87, 1998-2001, 2007/08 and 2011, Uganda experienced below normal rainfall resulting into severe drought in many parts of the country with the worst drought occurring in 1979 to early 1980s. This climate extreme is still clear in the memories of many of the Ugandan population especially the elderly irrespective of whether they are living in urban or rural areas. It was a period of intense hunger as agricultural land could not yield any output and households' food piles were depleted (UNAPA, 2007). From the Republic of Uganda (2010) policy document, it is reported that during this period, food insecurity increased, many Ugandans suffered from ill health and children were malnourished and it is reported that people died due to hunger in worst hit drought areas (e.g. Karamoja region). This also resulted into increased reported cases of household level conflict and violence. Denton (2002) argues that climate extremes such as droughts and famine increase conflicts at household, community and regional levels.

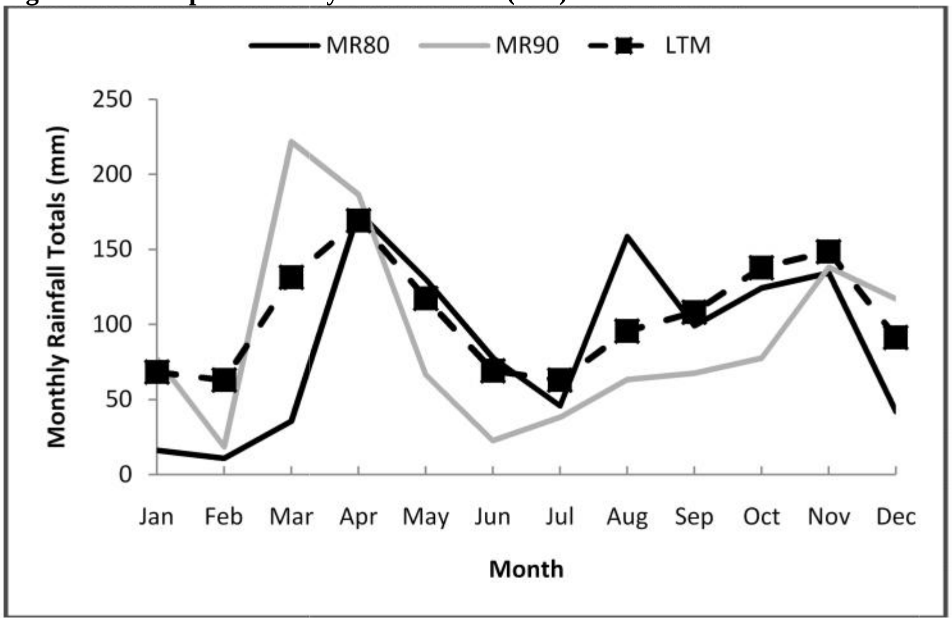
However, from Figure 3.2, in 1985, 1997, 2007/08 and 2010/11, above normal persistent unexpected rains were recorded at all weather stations. This implies that in these years severe floods occurred in many parts of Uganda. For example, the 2007/08 and 2010/11 floods caused major landslides/mudslides in the eastern part of the country along the Mt. Elgon slopes in Bududa district (Republic of Uganda, 2011). According to NEMA (2007) report on the status of the environment, high population growth in the east hassled to the encroachment on mountain slopes for agricultural production. Coupled with bad farming practices, this has led to land fragmentation resulting into mudslides/landslides when prolonged rains occur.

(ii) Onset and cessation of the seasonal rainfall patterns

We define '*onset*' rainfall as the period when rain is expected to start and '*cessation*' as the period when rainfall is expected to stop. Most parts of Uganda receive *bi-modal* rainfall patterns with first season onset long rains expected from March-May and second season onset short rains from September- November. Rain usually ceases between seasons for the months of June- August and then December-February. The northern region of the country receives a *uni-modal* type of rainfall i.e. one long season rains from mid-April to end of October with slight relaxation in July and long dry spells from mid-November to mid-March.

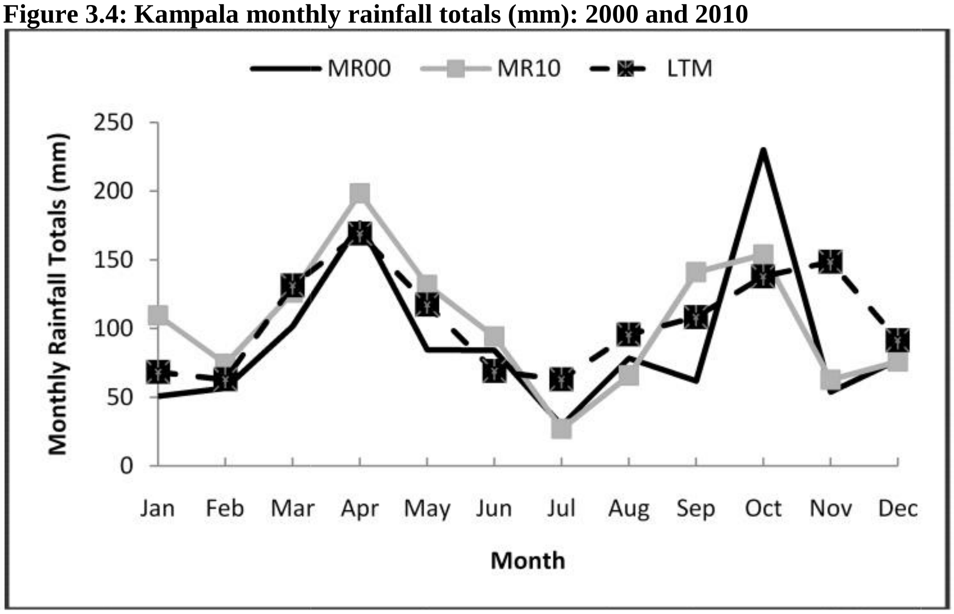
For this second indicator of climate change, we establish that Uganda's climate change has altered onset and cessation of seasonal rainfall patterns. Thus, we look at how rainfall monthly totals (mm) have deviated from the LTM (Figures 3.3-3.10). The LTM is calculated and provided by the UDoM. We present our results using line graphs by super imposing the LTM curve on the monthly rainfall totals for each year and observe the trend in deviations between the two curves. As before, analysis is done by weather station. Given that it is tedious to present graphs for each weather station over the 32 year period, for simplicity, chosen are years with 10 year gaps. Thus, monthly rainfall (MR) totals for years1980, 1990, 2000 and 2010 are used. To limit biases in anomalies, years chosen had almost no ENSO interference on expected normal rainfall patterns.

Figure 3.3: Kampala monthly rainfall totals (mm): 1980 and 1990



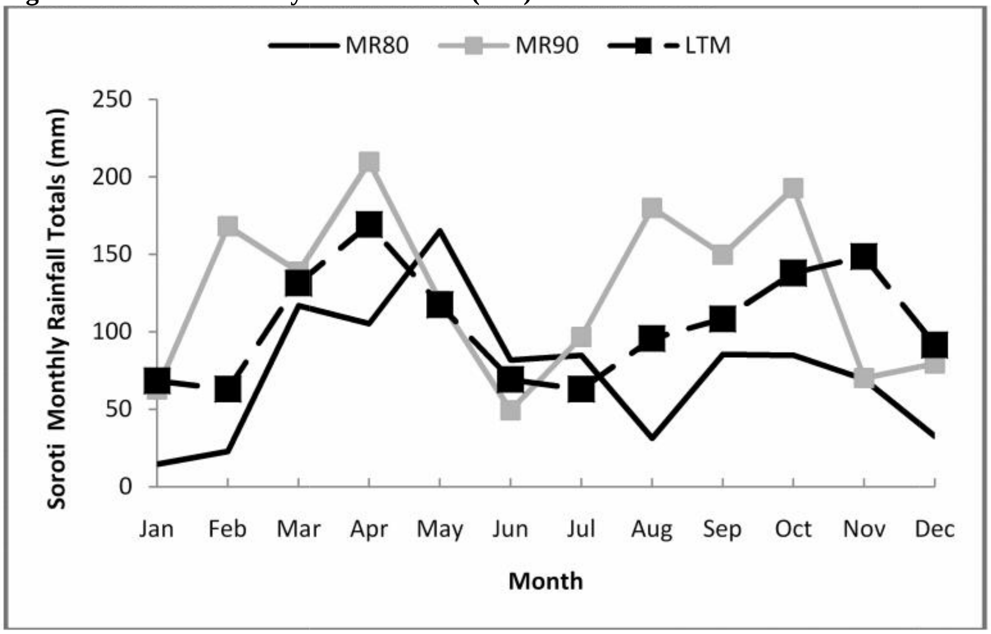
Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Figure 3.4: Kampala monthly rainfall totals (mm): 2000 and 2010



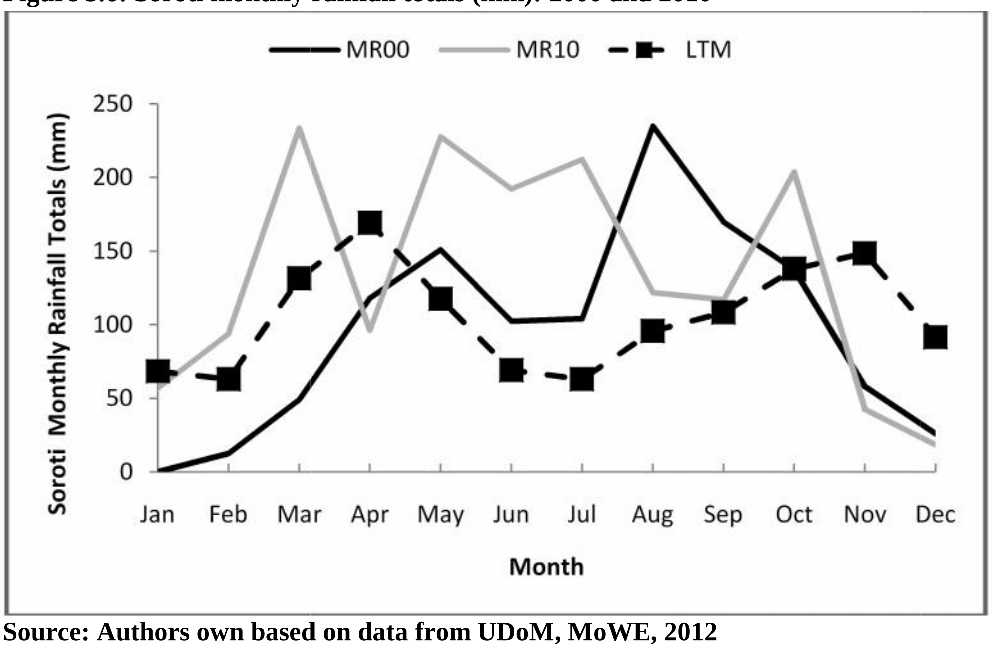
Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Figure 3.5: Soroti monthly rainfall totals (mm): 1980 and 1990



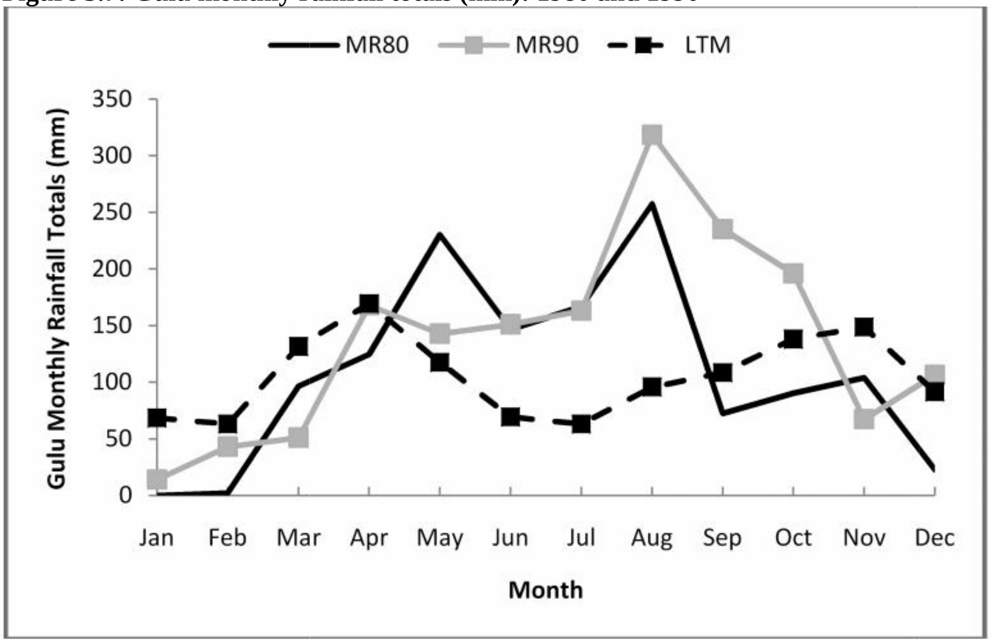
Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Figure 3.6: Soroti monthly rainfall totals (mm): 2000 and 2010



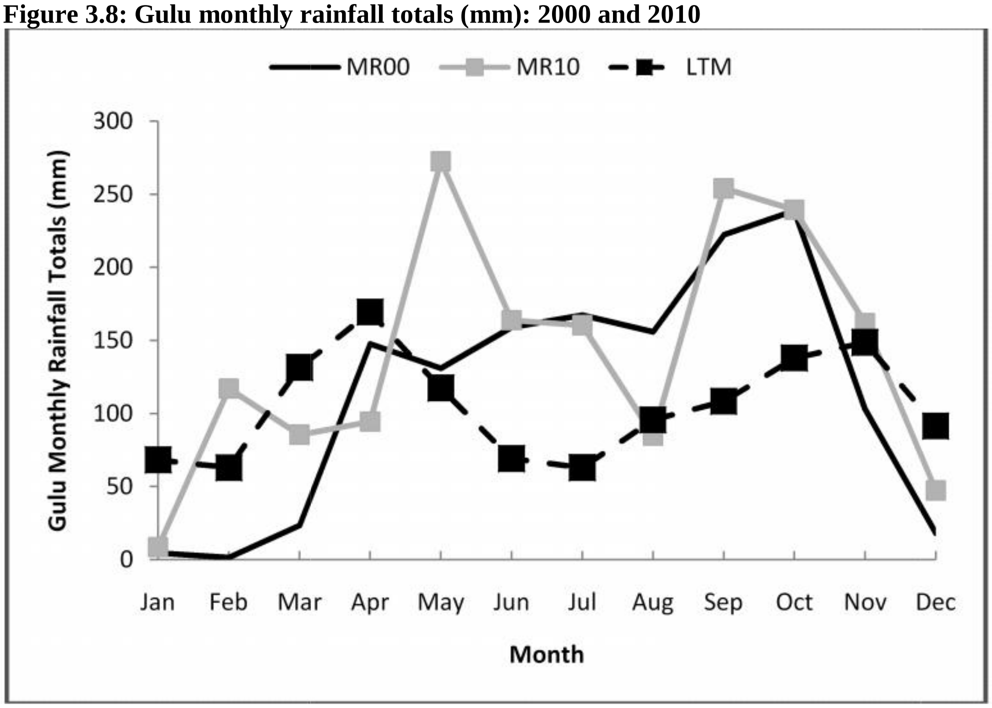
Source: Authors own based on data from UDoM, MoWE, 2012

Figure 3.7: Gulu monthly rainfall totals (mm): 1980 and 1990



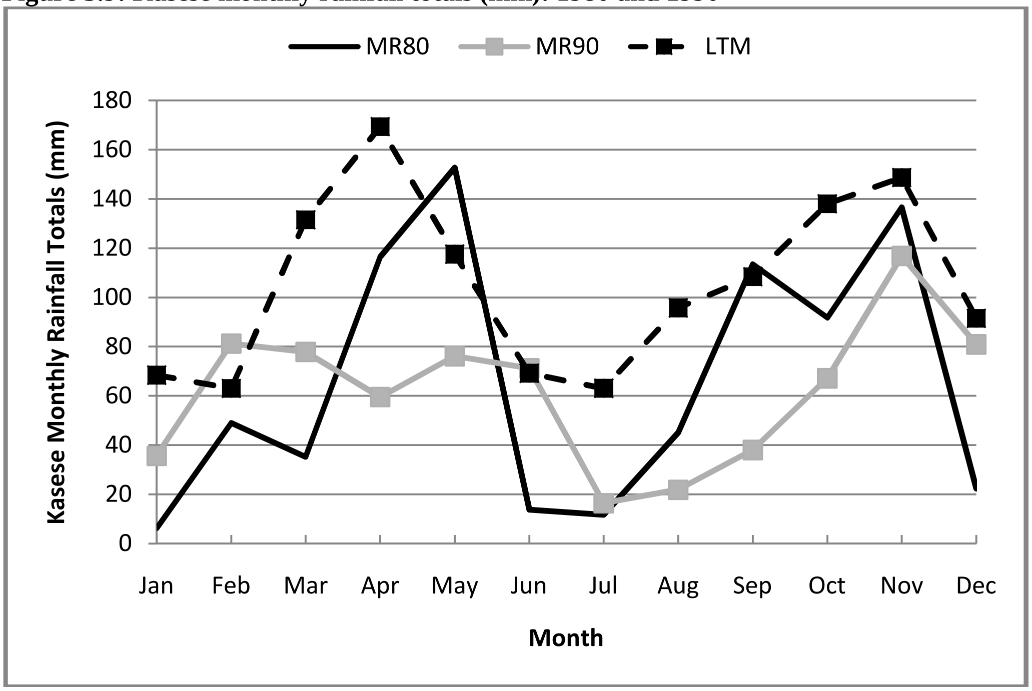
Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Figure 3.8: Gulu monthly rainfall totals (mm): 2000 and 2010



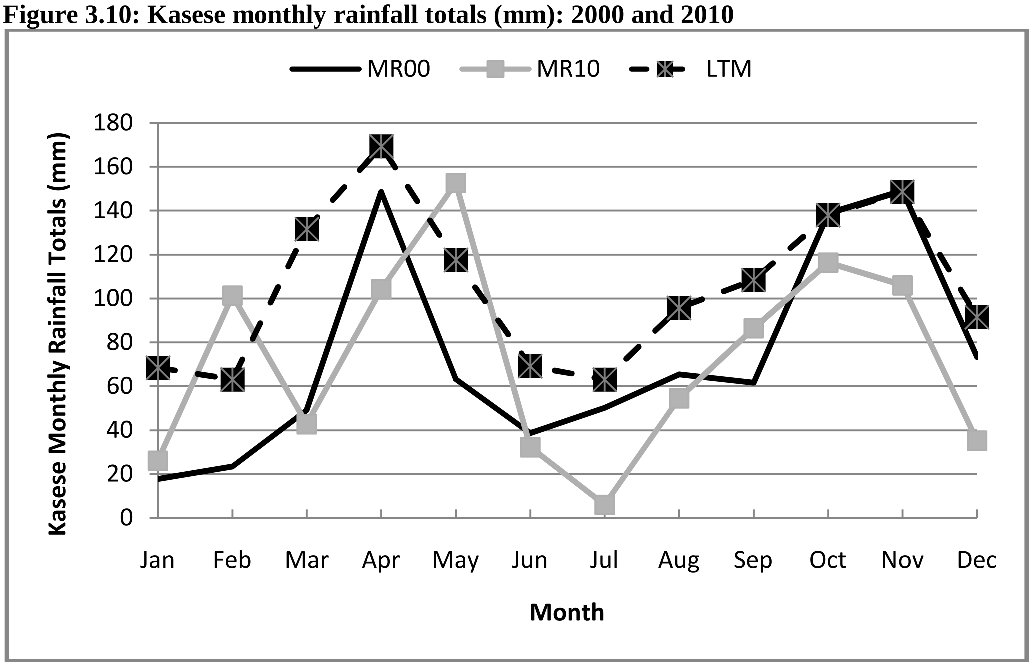
Source: Authors own based on data from UDoM, MoWE, 2012

Figure 3.9: Kasese monthly rainfall totals (mm): 1980 and 1990



Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Figure 3.10: Kasese monthly rainfall totals (mm): 2000 and 2010



Source: Authors own based on data from UDoM, MoWE, 2012

Findings presented in Figure 3.3 to Figure 3.10 show that for almost all weather stations other than Kampala station, the rains either started earlier than the postulated month or started late into the month. Intuitively, unexpected rainfall patterns during cropping seasons distort farmer's agricultural activities. That is, farmers essentially start planning and planting crops only for rains to cease a month later, destroying crops (in most cases seeds rot in the ground before they sprout) due to false first season start of rains (FEWSNET, 2010). In this regard, for the Kampala weather station, there is no discernable pattern from the deviations of monthly rainfall totals in 1980, 1990, 2000 and 2010 from the LTMs. But stations such as those located in Soroti, Kasese and Gulu indicate that onset rains received are above the LTM especially in 2010. This creates excess moisture in the ground, delays in ripening of crop which in-turn leads to premature low yield, if any (UN-Humanitarian Profile, 2011, 2012; FEWSNET, 2010). The wide deviations observed in onset and cessation of rainfall trends from the LTM for many of the weather stations provide an indication that indeed climate change is occurring and it is altering cropping season's rainfall patterns (see similar arguments and evidence in the IPCC, 2001 report; Archer, 2012).

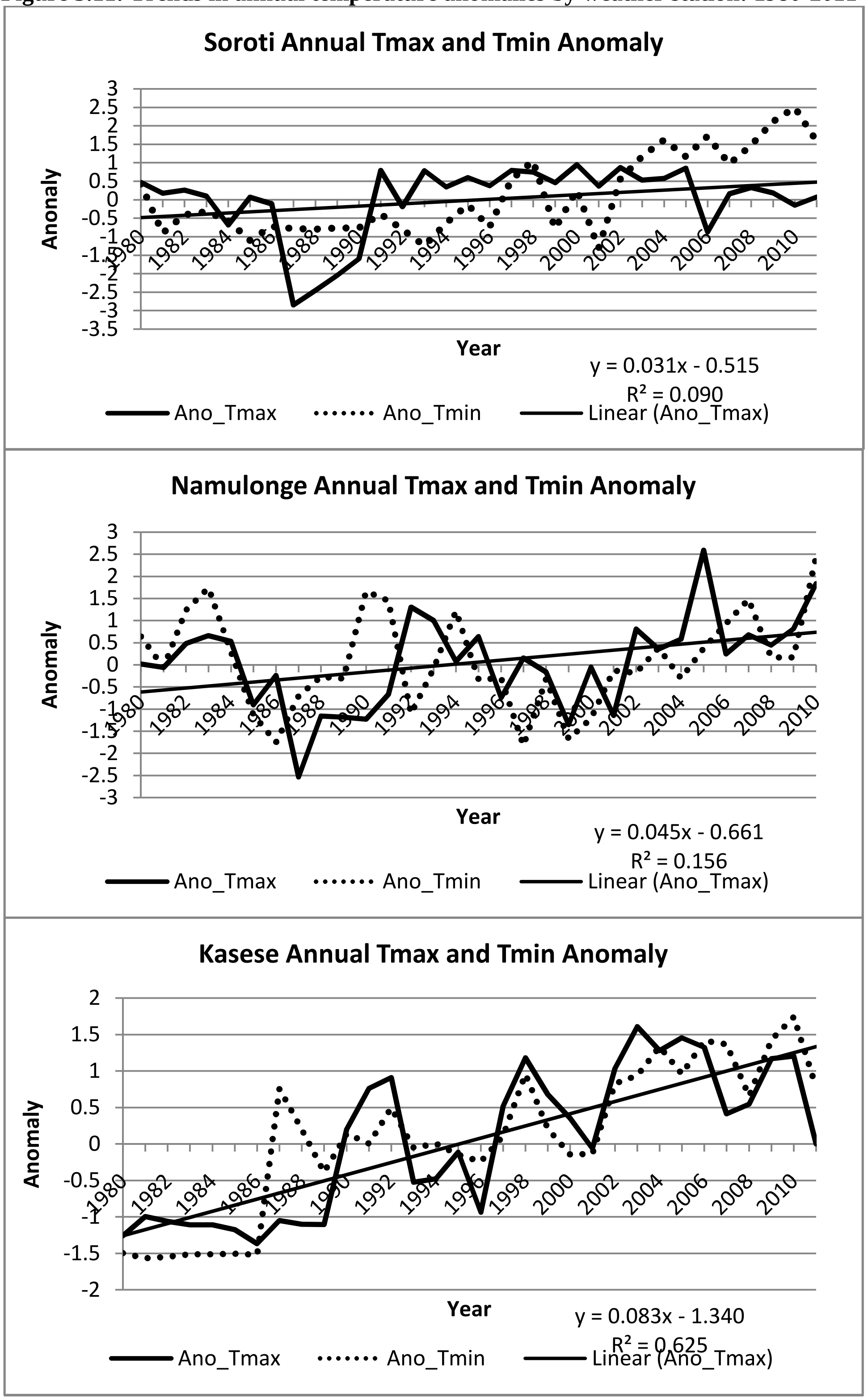
(iii) Trends in temperature patterns

Here, anomalies in temperatures if plotted and lay outside the ±0.5 bands, then we conclude that climate change has shifted temperature up or below normal expectations. As in rainfall trend analysis, a linear trend line is added (here the trend line captures maximum temperature anomalies only). If the temperature gradient is positive it implies an increase, negative gradient implies a decrease and a zero gradient implies no change in maximum temperatures over time.

From Figure 3.11 and Appendix A-Figure A.2, all weather stations show that maximum and minimum temperatures are increasing steadily. The Jinja weather station (located in Zone 5) indicates a drop in maximum temperatures over the years while minimum temperatures indicate a steep positive trend. Interesting to note are the two weather stations in the west (climate zone 8) that is Kabale and Mbarara stations. Despite observable minimal increases in the maximum temperatures recorded, the minimum temperatures indicate a steep positive trend as found for the station in zone 5. In sum, temperatures increased in almost all weather stations. Kabale district is where the Mountain Gorillas, an endangered species of the world reside in the cold mountain slopes-Bwindi impenetrable forest reserve. In addition, Kabale usually has the lowest recorded temperatures in Uganda with temperatures as low as 4-8^0c (UDoM, 2010). According to statistics, minimum temperatures in Kabale have increased to 11^0C.

Recall that Kasese had a negative trend in rainfall received and a comparison with the temperature anomalies shows an increase in temperature trends both at the minimum and maximum. Intuitively, when rains become more sporadic, temperatures are more likely to correspondingly rise.

Figure 3.11: Trends in annual temperature anomalies by weather station: 1980-2011



Source: Authors own based on data from UDoM, MoWE, 2012

In comparing our anomalies in temperature with the ONI (Chapter 2-Table 2.2), the peaks for the various figures especially for the maximum temperature recorded in the years 1983, 1985, 1993, 1998-2000 and 2008/09 correspond to below normal SST in Table 2.2. The implication here is that, most parts of the country actually experienced above normal temperatures for extended periods of time leading to drought conditions. From our findings, we conclude that climate change effects are leading to hotter persistent temperature in which, minimum temperatures have been most affected. Simply put, it’s now hotter than before.

Comparison between temperatures, rainfall and agro-ecological climate zones

Having discussed extensively temperatures and rainfall anomalies, in here we understand another key term, *agro-ecological climate zones*. By 2010/11, Uganda had been divided into 112 administrative districts which increased to 114 by 2012. By 2006, lakes swamps and protected areas constituted 25 percent and more than 75 percent of the country (over 18 million hectares) was available for pasture and cultivation (Mwebaze, 2006). The capacity for this land resource to sustain rapidly increasing population largely depends on the influence of edaphic (relief and soil fertility), climate and biotic factors and how well they can be managed to increase and sustain its productivity. Thus, using the two wave Uganda National Panel Survey (UNPS) 2009 district codes and names and following World Bank (1993) and NEMA (1996), we have divided Uganda into seven broad agro-ecological zones which have similar economic and social backgrounds and in which ecological conditions (soil types, topography, rainfall and temperatures), farming systems and practices are fairly homogenous (Table 3.2).

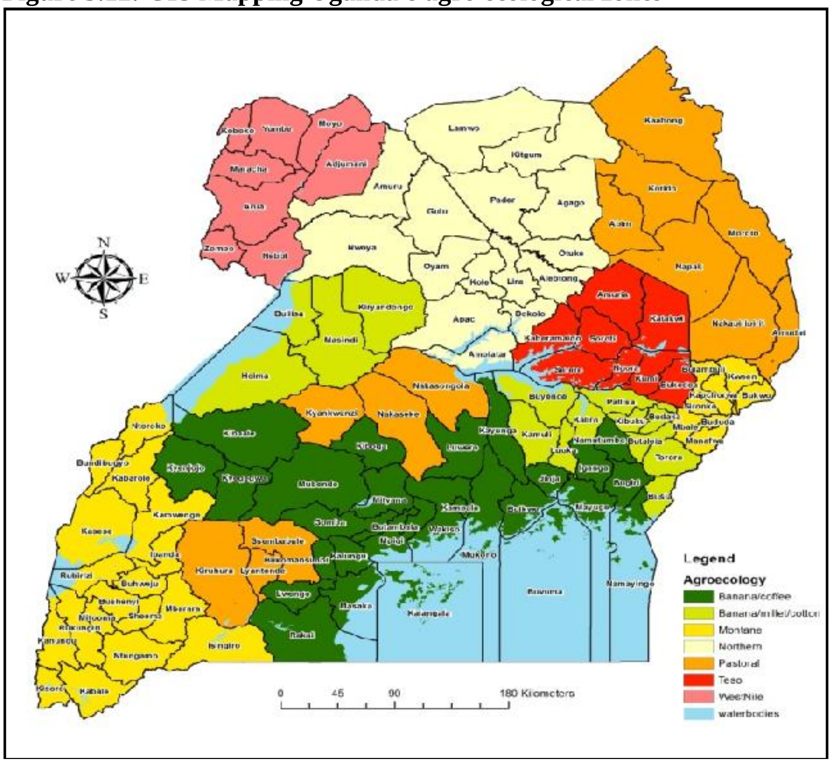
Table 3.2: Uganda's agro-ecological zones

Agro-ecology	Districts	Characteristics
Banana/coffee system	Bundibugyo, parts of Hoima, Kabarole, Mbarara, Bushenyi, Mubende, Luweero, Mukono, Masaka, Iganga, Jinja, Kalangala, Mpigi, Rakai, Kayunga, Wakiso, Lyandonde, Mitiyana, Nakaseke, Bugiri, Mayuge, Masindi, Kyenjojo, Kibaale, Namutumba, Buliisa and Kampala	Equable climate and evenly distributed rainfall on medium to high productivity soils. Vegetation is mainly forest/savanna mosaic with pastures suitable for intensive livestock management. Banana and coffee are the main crops with root crops on the increase. Livestock is generally not integrated into the system but it can be an important source of income.
Banana/millet/cotton system	Kamuli, Pallisa, Tororo, parts of Masindi, Busia, Hoima, Nakasongola, Budaka, Kaliro and Luweero	There is greater reliance on annual food crops (millet, sorghum and maize) since rainfall is less stable than under the Banana-Coffee System. In the drier areas livestock is a main activity.
Montane	Kabale, Kisoro, parts of Rukungiri, Kasese, Kabarole, Bundibugyo, Mbarara, Mbale, Kanungu, Bushenyi, Kamwenge, Sironko, Buduuda, Bukwo, Manafwa, Ibanda, Isingiro, Kiruhura and Kapchorwa	Higher elevation with cool weather, high effective rainfall and cloud cover. High population density with smaller sized holdings. Bananas are a major staple as well as sweet potatoes, cassava and Irish potatoes. Arabica coffee is prevalent above 1600 metres.
Teso system	Soroti, Kumi, Amuria, Bukedea and Kaberamaido	Characterised by bi-modal rain falling on sandy-loam medium to low fertility soils. Main staples are cassava, millet and maize. There is short grassland ideal for grazing. Use of crop residues is very common
Northern system	Gulu, Lira, Apac , Oyam, Amolatar, Dokolo, Amuru and Kitgum	Mono-modal annual rainfall (1000-2000 mm) adequate for most crops but the intensity of the dry season requires that drought tolerant annuals are cultivated (finger millet, sesame, cassava and sorghum). Tobacco and cotton are major cash crops. There is short grassland where communal grazing abounds.
Pastoral system	Kotido, Moroto, parts of Mbarara, Ntungamo and Masaka, Ntungamo, Masaka, Nakapiripirit, Ssembabule, Kaabong and Rakai	The pastoral system is characterised by short grassland where nomadic extensive grazing is practiced. Multi species grazing is common but appropriate cattle/small ruminant ratios for optimum utilisation of the grassland have not yet been achieved.
West-Nile system	Moyo, Arua, Adjumani, Yumbe, Nyadri and Nebbi	Rainfall patterns are similar to the northern system with greater rain at higher elevation. Intercropping is common with a wide variety of crops. The system is in the sub-humid zone and livestock activities are limited by the presence of tsetse fly.

Source: Author's own categorisation from Panel dataset, 2012

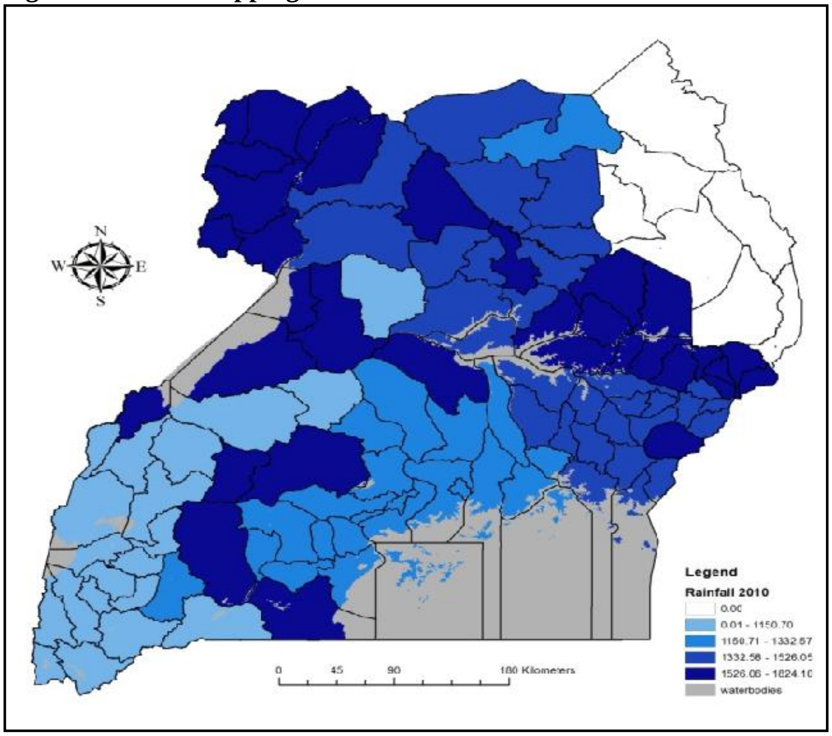
These were then split into subzones identified by factors such as similar crop combinations, size of holding, average plot sizes and yields. Based on these divisions, defined mapping units (using Geographical Information System (GIS) software ArcMap 10) were worked out together with outlines of potential use as a basis for zoning, stratification for production and climate (Figure 3.12).

Figure 3.12: GIS Mapping Uganda's agro ecological zones



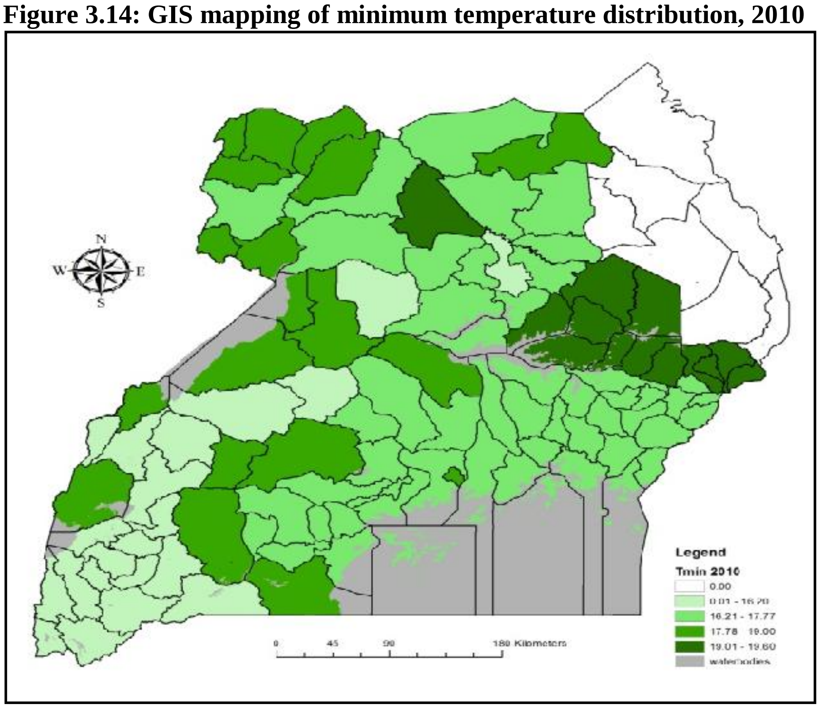
Source: Author's own map based on UNPS

Figure 3.13: GIS mapping of rainfall distribution in 2010



Source: Authors own based on UDoM, 2012 data

Figure 3.14: GIS mapping of minimum temperature distribution, 2010



Source: Authors own based on UDoM, 2012 data

From Figure 3.12, 3.13, and 3.14, there is a fairly high level of similarity between the agro ecological zones to rainfall and temperature distribution across the country. Given that agro-ecological zones encompasses more than climate indicators, in chapter four and five, other than use temperatures and rainfall as variables in our estimations, we make use of agro-ecological zones in our analysis[9]. The use of agro ecological climate zones has an added advantage given that all temperatures and rainfall data per district have incomplete available data while agro ecologies are easily generated from the survey data sets. This provides consistency in the analysis as our climate related indicator and socio economic data are from the same source with identical units of measurement (households) leaving no room for error in estimations.

3.5 Conclusion

In this chapter, identified are factors determining climate. We analysed climate variability and change using LTMs and standardised values to generate anomalies, which are then utilised to assess the extent of climate variability and change in Uganda. A clear relationship between climate change, frequent and persistent occurrence of extreme climate distress event and the ENSO-ONI was discussed in detail. We noted that rainfall and temperatures move in tandem. That is when rains are below normal, extremely high temperatures are more likely to occur and vice versa. We also concluded that climate is varying and changing from its natural course in Uganda and it has indeed

[9]Because of the difficulty in attaching/matching administrative metrological data (objective measures of climate e.g. temperatures, rainfall and humidity) to a specific household in survey datasets in analysis of climate change at micro level, we use agro ecological climate zones as recommended by Deressa et al. (2008) and Below et al. (2010).

altered rainfall, temperatures and onset and cessation of rainfall patterns. Such variability and change in climate have differential impact on households' especially agricultural households and the poor. In addition, expected differences in impacts imply expected differences in adaption strategies employed to mitigate frequent occurrences of climate extremes (droughts and floods). The adaptation measures are neither gender neutral, nor, are they automatically expected to be welfare improving. The next chapters explore and examine these aspects in detail. The key limitation in this chapter is that it would have been of value addition to map vulnerability to natural disasters by agro-ecological zone. However, vulnerability mapping of households to natural disasters requires its own set of variables and methodologies which are beyond the scope of this study.

CHAPTER FOUR

ADAPTATION TO CLIMATE CHANGE IN UGANDA: A GENDER PERSPECTIVE

4.1 Introduction

This chapter examines climate induced shocks, and choice of adaptation strategies to these by gender[10] of the household head. Further identified and analysed are the factors determining adaptation choices for each covariate[11] shock for male and female headed households. This chapter specifically analyses some of the gender differences in adaptation to shocks experienced at household level emerging from panel surveys. The analysis is by sex because the way gender is operationalised in a given context is through the respondents' sex. The recognition of the differential impacts of climate change on men and women have led to the inclusion of gender in adaptation to climate change policy agenda in recent times (UNDP, 2010; IPCC, 2012). According to the IPCC (2012) report, men and women will not respond the same way when disasters occur such as floods, droughts, crop and livestock endemics, mudslides and storms. For instance, Denton (2002; 2004) argues that in many sub-Saharan countries, rural household income and food security have become women's business during drought. In addition, the double reproductive and productive burden placed on women with diminished support

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[10]Gender is widely used to refer to the socially constructed differences and distinctions between men and women. It is a culturally specific set of characteristics that identifies the social position of women and men and the relation between them. The different roles played by women and men and the imbalances in access to resources, power, economic opportunities due to low bargaining power, among other reasons simply on account of one's gender are in existence at varying degrees (UBoS, 2006).

[11]These are climate induced shocks that have massive impacts on communities and can trigger one or more shocks. Climate change will exacerbate covariate shocks through increased occurrences of droughts, floods, hailstorms/mudslides, crop pests and livestock epidemics.

from men, have grossly undermined rural livelihood security in times of risks (Aguilar, 2008).

In response to climate risks, Agarwal (1997), Denton (2002) and Alston (2006) assert that men are more likely to migrate and leave behind their families in search of secondary employment or asset sale e.g. livestock and land while women are more likely to stay behind and face the situation either by scaling back on food intakes, skipping meals, selling their jewellery or living on charity. Such dynamics have patriarchal inclinations ingrained in land and/or asset ownership, access to credit and more basically the role of a woman and a man in the family (Agarwal, 1997; Ellis et al., 2006 and Bategeka et al., 2008).

In Uganda's National Development Plan (NDP), gender is identified as a cross cutting issue. Uganda, a typical low income sub Saharan economy, is largely agrarian and rural. Women and children contribute over 70 percent of the labour force in agricultural production and usually unpaid family workers (UBoS, 2010). Implying that, the negative impacts of climate change affect women and children more than men due to their higher involvement in agricultural related activities. It is noted in the UBOS (2010) report that women work on land they do not own and spend more time in care activities (such as cooking, fetching water, caring for the sick) than economic activities (such as any form of business and wage employment). Such divisions in asset ownership and time spent in sector of employment have gender implications in regard to adaptation strategies employed during climate disasters.

Thus, as in most micro-studies, we use the subjective measures[12] of shocks to climate change as opposed to the objective measures[13] in categorising choices of adaptation strategies for each covariate shock while controlling for gender of the household head. We further quantitatively examine factors influencing the adaptation strategies to climate distress events. The results presented in this chapter are at the household level unless otherwise stated. The rest of the chapter is organised as follows: discussed in Section 4.2 is the relevant literature on gender and adaptation to climate change, Section 4.3 presents the methodology employed with the underlying reasons for model choice outlined, variables choices and hypothesises tested are also discussed, and Section 4.4 describes the data transformation and sources. Presented in Section 4.5 are the descriptive statistics, econometric results, analysis and discussion while Section 4.6 concludes the chapter.

4.2 Previous research on gender and adaptation to climate change

IPCC (2007; 2012) and Smit et al. (2000) define adaptation as a response to (potential) environmental stimuli that affect given entities, subjects or systems. That is, adaptations

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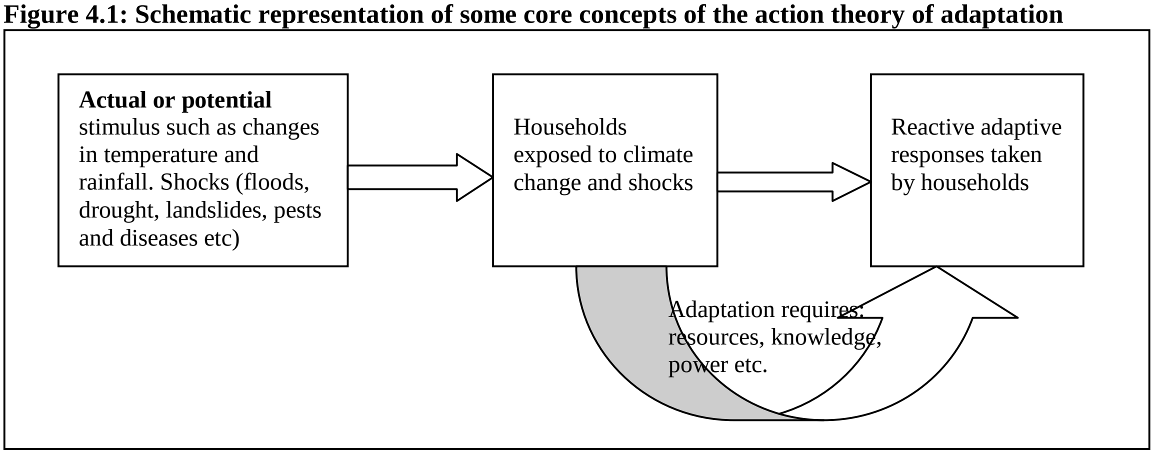
[12]Subjective measures are those usually derived from answers to a shock and coping strategy section incorporated in household survey questionnaires asking responds whether they experienced different types of shocks over a certain period (e.g. drought, floods, pests, landslides, hailstorms, livestock epidemics).

[13] Objective measures are those derived directly from weather data, these measures are often constructed only at a rather aggregated level.

are processes within entities and systems, or adjustments made by human systems. However, Eisenack and Stecker (2011), specifically refer only to human individuals and collective actors in defining adaptation. This study follows the Eisenanck and Stecker (2011) definition in which we restrict our definition to adaptations that are made by human actors as a result of exposure to climate change and disasters that arise herein. Figure 4.1 illustrates the adopted definition more clearly.

Figure 4.1: Schematic representation of some core concepts of the action theory of adaptation



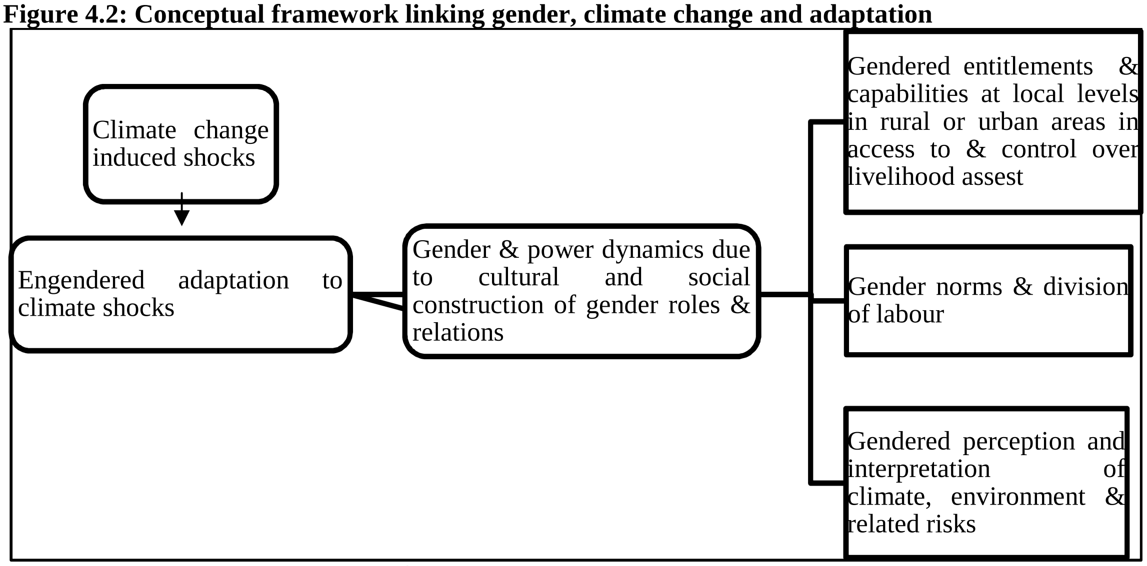
Source: Adopted and modified from Eisenack and Stecker (2011).

From Figure 4.1, adaptation takes place when a household is exposed to any form of stimulus. In the theory of adaptation, a “stimulus” is defined as a change in biophysical (in particular meteorological) variables associated with climate change.

Farmers continuously adapt to climate variability at the local level. They change crops or varieties, choose different harvest and sowing dates, alter land management and employ water efficiency techniques (FAO, 2007). Long-term climate change poses a new set of challenges to farmers dependent on natural resources. As a result at the national and international levels, governments and development agencies must play a fundamental role in building the capacity of farmers to cope with and adapt to a changing environment (Soussain, et al., 2003). However, until recently, international climate change policy makers have neglected the gender dimension of climate change (Lambrou and Piana, 2006a). The adaptive capacity of people depends on how they can draw from resources to maximise their livelihood outcomes (Masika, 2002). So, adaption depends on factors such as economic status, technology, health, education, information, skills, infrastructure, access to assets, and management capabilities (IPCC, 2007; 2012).

We adopt the Oxfam and United Nations (2009) conceptual framework to further contextualise the link between gender and adaptation to climate change (Figure 4.2). The framework provides an overview of key aspects of climate change and gender linkages.

Figure 4.2: Conceptual framework linking gender, climate change and adaptation



Source: Author's own based on Oxfam and United Nations, 2009

In relation to Figure 4.2 concept, Masika (2002) argues that the differentiated power relations between men and women and unequal access to and control over assets means that men and women do not have the same adaptive capacity. Instead, women have distinct vulnerability, exposure to risk, coping capacity and ability to recover from climate change impacts. The author concludes that although women are generally more vulnerable to the impacts of climate change, they play an active role in adapting to its impacts to secure food and a livelihood for their household.

Insights from FAO (2005) indicate that gender determines adaptive strategies. For example, gender assigns differential roles in agro biodiversity management and women often have greater knowledge of indigenous plant varieties with important nutritional and medicinal values. Women often have knowledge of a variety of genetic resources that are used to adapt to varying climate conditions such as resistance to drought or pests. However, because men have more secure access to land or land tenure, they have more incentive to contribute to effective natural resources management, use and contributions necessary for adaptation.

In support of FAO (2005) findings, Patt et al. (2009) further argues that different gender attitudes towards risk responses exist where men are more likely to take risks than women and in decision making processes whereas women are more likely than men to seek and listen to advice, and learn from others with more experience. Such intrinsic female tendencies make it easier for consulting agencies to offer help to women as they are more likely to take advice and carry out things that aid agencies suggest.

Frequently, new agricultural technologies bypass women farmers, despite women's knowledge. For example, extension personnel introducing new varieties intended for higher drought or heat tolerance, rarely speak directly with women farmers (Kurukulasuriya and Rosenthal, 2003). In this regard, a gender component exists for the adaptive strategies that are pursued. In regions impacted by drought, men migrate leaving women who have fewer resources to perform agriculture. In either case, the drought strains traditional gendered relationships (Alston, 2006).

In their paper, Aoyagi et al. (2011) point out that although many societies still have gender-bias tendencies in their social systems, many are trying to overcome them. Nonetheless, gender biases still exist in rural settings especially in division of work. They give an example based on Japanese society where gender biased attitudes are still strong despite Japan's level of development. Using three case studies on three female farmers in Japan, they reveal that climate change impact on Japanese agriculture (food supply sectors) has seen the quantity of rice and fruits declining, and orchards projected to relocate. The adaptation strategies they proposed and which farmers were undertaking included development and introduction of varieties of rice or other crops that tolerated higher temperatures, relocating fields and changing or adjusting cultivation methods.

Aguilar et al. (2007) discuss gender and climate change impact in the general context of developing countries. According to the authors, “Women are the main producers of the world’s staple crops, providing up to 90 percent of the rural poor’s food intake and producing 60–80 percent of the food in most developing countries.” As a result, the impact of climate change in agricultural production has the potential to cause severe food shortages across the world, but the rural poor and women are most affected. They also emphasise that, “Climate change does not affect women and men in the same way, such that a gender-differentiated impact arises. Therefore, all aspects related to climate change (i.e., mitigation, adaptation, policy development, decision making) must include a gender perspective.”

The relationships among gender, human rights, and poverty in the context of climate change adaptation have been widely studied (e.g., Denton 2004; Demetriades and Esplen, 2008; Polack, 2008; Terry 2009; Hertel et al., 2010). In these papers, women are often described as victims of gender-biased social systems. Demetriades and Esplen (2008) discuss the “gender–poverty–climate change nexus,” which includes physical and mental health, ascribed and legal inferiority, discrimination in the labour market, poverty of time, lack of political clout, insecurities, conflict related to climate change, and cultural constraints. They also state that women have already begun to learn how to adapt to some of these challenging conditions. Terry (2009) writes that there can be “no climate justice without gender justice.” She discusses how poor men and women have to cope with climate risk adaptation without much help. She also points out that culturally and financially restricted poor women and men are affected by the climate risk unevenly and that women are even more restricted in response to the risk. In addition, if farmers lose their land, they respond by findings jobs in other sectors. Often this means they will become wage earners and become even more vulnerable to climate change impacts (Hertel et al., 2010).

Hepworth and Goulden (2008) discuss Uganda's country specific information on climate change characteristics, national priorities, and current and planned initiatives. Their findings show that the seasonality of rainfall is likely to change in the future. With reference to Lake Victoria, they note that populations around Lake Victoria are likely to make some adaptations to climate change without intervention from outside. That is people are likely to try and diversify their livelihoods, fisher men are expected to move between different lakes and landing sites and people will make use of their networks of friends, relatives and acquaintances at the time of crisis. The current policies and plans on climate change issues are inadequate (are not considered priority action areas and hence not well action oriented) and also lack international finance to support adaptation. As a result, policies are either gender neutral or gender blind (Hepworth, 2010).

According to UN-HABITAT (2009), inclusion of gender is not only important in understanding the vulnerability and effects of climate change in Uganda but also in trying to devise adaptation measures as women and girls comprise 51.19 percent of the national population. Women play an important role not only in the national and urban economies but also in the social and environmental arena. Women's triple gender roles of reproduction, economic and social roles, and their responsibilities including providing for their households and engagement in livelihood strategies make them the cornerstone of household welfare. These roles necessitate the need to analyse gender and adaptation to climate change. They conclude that adaptation measures and mitigation should mainstream gender in adaptation strategies and policies. Further, household adaptation measures are likely to take root if women are included in adaptation projects. Therefore, climate change adaptation and mitigation need to be gender responsive.

Empirical research on adaptation and factors determining choices of adaptation to climate change, at case study and country level, exists in Africa (e.g. Deressa *et* al., 2008; Gbetibouo, 2009; Hisali et al., 2011). In these studies, gender inclusion throughout the analysis is inadequate. More specifically, Deressa et al. (2008) use a Multinomial Logit model (MNL) to analyse farmers' choice of adaptations to climate change in the Nile Basin of Ethiopia. They use data from a case study cross-section of 1000 households. They also use Heckman Probit selection model and find that education significantly increases soil conservation by 1 percent and increases tree planting by 0.6 percent as adaptation choices. With regard to gender of the household head, male headed households adapted more readily to climate change. Specifically, 7.6 percent and 2.4 percent of the male headed households are more likely to plant trees and change planting dates respectively compared to female headed households. The inclusion of gender as an explanatory variable is not informative in engendering adaptation choices and factors influencing the decision making processes. In addition, policy recommendations made cannot be replicated nationally as analysis is at a case study level.

Following a similar approach in Deressa et al. (2008) paper, Gbetibouo, (2009) applies a MNL on a case study of farmers in the Limpopo River Basin in South Africa. A total sample of 794 farmers by household is used. Using a bottom-up approach and the Kruskal-Wallis test, a non-parametric test, to assess farmers' perceptions on climate, the author finds that farmers' perceptions of climatic variability are in line with climatic data records for the region. They also find that although farmers are well aware of climatic change, few seem to have taken steps to adjust their farming activities. Approximately 30 percent of farmers adjust their farming practices to account for the impacts of climate change. The paper concludes that the main adaptation strategies of farmers in the Limpopo River Basin include switching crops, changing crop varieties, changing planting dates, increasing irrigation, building water-harvesting schemes, changing the amount of land under cultivation, and buying livestock feed supplements. All the adaptation choices employed are agricultural technology related. This study has similar limitations as those in Deressa et al. (2008) study.

On a country level, Hisali et al. (2011) analyse factors that govern choice of adaptation mechanisms to climate change using a cross sectional Uganda National Household Survey, 2005/06 (UNHS III) dataset. Using the MNL and tests for IIA assumptions, they find that reducing consumption, use of savings and technology are the most commonly used adaptation strategies to climate shocks (such as drought, livestock epidemics, pest attacks and floods) with borrowing being the least utilised choice. Using the MNL, they identify factors that explain the choice of response strategies to different climate shocks. They find that age of household head, access to credit and extension facilities and security of tenure were invariant across some climate shocks. They further note differences in the choice of the adaption strategies by agro-ecological climate zone. Deressa et al. (2008) and Hisali et al. (2011) argue that this reflects the relative importance of indigenous knowledge and externalities in climate change adaptation. In addition, older farmers are less likely to reduce consumption pointing towards their relatively higher vulnerability. They conclude that polices that smooth consumption patterns of households and those that cub population growth in order to reduce pressure on agricultural land need to be implemented. Again, as in most empirical studies, gender is included as an explanatory dummy variable. This is a major limitation in policy implementation as adaptation measures at household and country level should not be uniform for all genders. This study specifically builds on Hisali et al. (2011)'s work with a gender focus. In addition, other than use cross section data, the study utilises a more recent Uganda National Household Panel Survey (UNPS) dataset. Thus, our empirical findings yield novel insights in the gender and adaptation to climate change debate at both household and country level.

The only empirical study to my knowledge that has endeavoured to empirically analyse the determinants of adaptation to climate change with a gender bias (for male and female headed households) is by Nabikolo et al. (2012). This study focuses only on the eastern region of Uganda, an area where mudslides/landslides occur. They use a logit regression on 136 households to identify factors that determine adaptation to climate change. They find that climate change decisions for female heads are influenced by liquid assets while for male heads are influenced by real estate especially land. Other demographic characteristics included do not play a significant role in decisions to adapt to climate change across households. Their research shows that factors that influencing climate change adaptation decisions for female heads are different from those that influence adaptation decisions for male heads. They recommend for gender differentiated interventions to promote/incentivize climate change adaptation. This study is biased towards one region and one climate shock (mudslides caused by floods). Given that adaptation is captured as a binary dependent variable, this limits our understanding of the actual forms of adaptation strategies being employed by female and male headed households and actual factors governing these choices. Our study fills this gap and extends analysis to a national level covering all types of climate shocks reported by households using the UNPS.

In conclusion, there is a wealth of qualitative and narrative literature that delves into the role of gender in adaptation to climate change. Studies exist that have empirically quantified adaptation and factors determining adaptation choices to climate change in Africa. Further noted is that although some studies are gender sensitive and partially address gender, however, majority of the empirical studies are gender neutral or gender blind. In addition, these studies neither include gender in their objectives, nor suggest gender responsive interventions in adaptation to climate change.

4.3 Methodology

To address one of the objectives of this chapter, we employ a pooled Multinomial Logit (MNL) model [14] to identify factors influencing choice of adaptation strategies to covariate shocks for male and female headed households. The MNL model assumes independence of irrelevant alternatives (IIA) [15] across outcomes and requires that the choice variables be mutually exclusive (Seo and Mendelsohn, 2006). The validity of this assumption is tested using the Hausman-McFadden (1984) test. In here, MNL model specification follows the action theory of adaptation discussed in section 4.2 (for details, Smit et al., 2000; Eisenack and Stecker, 2011). That is adaptation takes place when a household is exposed to any form of stimulus (in particular meteorological) indicators associated with climate change. Furthermore, two assumptions are made. First, households seek better adaptation strategies despite employing one already. Second, the household chooses an adaptation strategy based on its current situation. Thus, a

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[14] See Cameroon and Trivedi (2010); Greene (2012); Wooldridge (2012) for further reading.
At first, in addition to pooled MNL model estimates, the idea was to further estimate a Random Effects Multinomial Logit (REMNL) model on panel data that allows some or all parameters in the standard MNL model to vary randomly across households using GLLAMM commands in STATA developed by Rebe-Hesketh, Skrondal and Pickles (2004). But convergence over quadrature could not be achieved as one of the major limitations of GLLAMM is that, it is slow and often difficult to estimate REMNL in which the dependent variable has more than three categories. Hence, pooling panel data in the standard MNL model

[15] The IIA property states that for a specific individual, the ratio of the choice probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other alternatives i.e. all households are faced with the same set of alternatives.

household opts for a new coping strategy if the utility of the current coping strategy is lower than the alternative.

4.3.1 The model

The MNL model is based on random utility maximization principle and derived by introducing utilities U_{ij} for each agent i and choice j, where j is an index of the J possible categories of the polytomous response variable. It is assumed that the alternative with the greatest utility is chosen. The probability that the choice j is made is the following:

$$\text{—}_{ij} = \Pr(Y_i = j) = \Pr(U_{ij} > U_{ik} \neq k)_i \qquad (4.1)$$

The utility of choice j is modelled as:

$$U_{ij} = H_{ij} + £_{ij} \quad , \forall j$$

Where $H_{ij} = x \quad _j$ is the linear predictor, $£_i$ is a random error term and is independent and identically distributed (*iid*), x is a vector of case-specific explanatory variables including individual/household and climate characteristics.

The pooled MNL model can be derived assuming that the $£_i$'s are independent and identically distributed with a type I extreme-value distribution for all i:

$$f(£_{ij}) = \exp(-£_{ij} - \exp(-£_{ij}))$$

The MNL essentially compares any given outcome with a reference outcome. It is given as:

$$-_{ij} = \frac{\exp\left(X_i' \quad _j\right)}{\sum_{j=1}^{J} \exp\left(X_i' \quad _j\right)}, \ j = 1, \ldots, J \qquad (4.2)$$

Model (4.2) ensures that $0 < -_{ij} < 1$ and $\sum_{j=1}^{J} -_{ij} = 1$. In addition, to ensure model identification, $_j$ is set to zero ($_j = 0$) for one of the categories and coefficients are then interpreted with respect to that category, called the base category.

In the setting of a standard MNL model, the probability of jth alternative in equation (4.2) may be re-specified as follows:

$$-_{ij} = \frac{\exp\left(x_i' \quad _j\right)}{1 + \sum_{j=2}^{J} \exp\left(x_i' \quad _j\right)} \qquad (4.3)$$

Where $j = 1$ is the base category and $_1 = 0$ is an identification condition.

Equation (4.3) is estimated using a maximum likelihood estimator. The probability of an individual i to choose an alternative is expressed as follows:

$$\prod_{j=1}^{J} \left[\frac{\exp\left(x_i' \quad _j\right)}{1 + \sum_{j=2}^{J} \exp\left(x_i' \quad _j\right)} \right]^{y_{ij}} \qquad (4.4)$$

Where y_{ij} is if the probability of individual i choosing j and zero otherwise. Assuming that the observations are independent the likelihood for N observations may be written as:

$$\prod_{i=1}^{N}\prod_{j=1}^{J}\left[\frac{\exp\left(x_i^{'} \quad _j\right)}{1+\sum_{j=2}^{J}\exp\left(x_i^{'} \quad _j\right)}\right]^{y_{ij}} \qquad (4.5)$$

Taking the logarithm of equation (4.5) results in the following log-likelihood function:

$$\ln L(\quad) = \sum_{i=1}^{N}\sum_{j=1}^{J} y_{ij} \ln \frac{\exp\left(x_i^{'} \quad _j\right)}{1+\sum_{j=2}^{J}\exp\left(x_i^{'} \quad _j\right)} \qquad (4.6)$$

In estimating equation (4.6), the problem of omitted variables arises due the omission of some individual characteristics which can cause observations within individuals to be correlated overtime. The omitted variables can bias results of the empirical analysis if not properly solved, implying that the usual standard errors may be incorrect. Therefore, the Huber-White estimator is used to correct for individual heterogeneity in standard errors with additional corrections for the effects of clustered data at the household level.

4.3.2 Variable description

Dependent variable: Coping strategies, defined as household adaptation to covariate shocks.

The increased episodes and persistence of climate distress events as discussed in earlier chapters appear to be indicative of long term climatic changes and in line from reports on climate change in Uganda such as LTS International (2008) and Republic of Uganda (2007). In response to identified climate shocks (drought, floods, crop pests and livestock epidemics), households have been employing a range of coping strategies. The panel surveys identify mortgaging household assets, selling assets, using past savings and withdrawing children from school, as some of the adaptation/response mechanisms. Other strategies include sending children to live elsewhere, migration, formal borrowing, informal borrowing, reducing consumption, and reliance on help from relatives, friends and local governments. More wage employment, changing crop choices to avoid bad weather, improving technology (use of irrigation, fertilizer, pesticides & marticides), working as self-employed, and increasing agriculture labour supply were also included.

Following empirical literature on adaptation to climate change[16], the above coping strategies are in turn collapsed into five coping (unordered) adaptation strategies that are mutually exclusive[17] for a given covariate shock. These include (i) borrowing-both from formal and informal sources; (ii) labour supply- increasing wage employment, working as self-employed, increasing agriculture labour supply, migration to work elsewhere and withdrawing children from school and sending them to work; (iii) reducing consumption-reducing food intake and skipping meals; (iv) savings-using up assets and past savings including mortgaging assets, selling assets and utilising savings; and, (v)

[16]See Deressa et al. (2008); Below et al. (2010); Hisali et al. (2011)

[17]The question asked "how did your households cope with this event? Give multiple answers up to three; with rank 1 for first choice". To attain mutually exclusiveness, only choices that had a rank of 1 were chosen for analysis.

agricultural technology based adaptation strategies such as changes in crop choices to avoid bad weather and improving technology.

Thus, based on the five formulated categories, choices of coping strategies for each covariate shock are generated for analysis.

Control variable: Gender of household head

The head of household in these surveys is defined as "the one who manages the income earned and expenses incurred by the household, and is considered by other members of the household as the head (see UBoS, 2006; 2010)." The household head can either be male or female, and is not necessarily the oldest person in the household[18]. From Table 4.1, we observe that the proportion of married female and male headed households increased between the surveys with a higher proportion being male headed. Also, noted is that, a high proportion of divorced/separated households were female headed. There was a decline in households who were never married for both female and male headed households. Polygamous marriages are higher in rural areas than in urban areas.

[18]Many households live with extended families. Where by the old move in with their children or some children move back home after school, become bread winners and decision makers. For this study, we use the aggregated female and male headed households regardless of their marital status.

Table 4.1: Marital status by residence and gender of household head (% of total)

Marital status	Female headed						Male headed					
	2005/06			2009/10			2005/06			2009/10		
	Rural	Urban	***All***	Rural	Urban	***All***	Rural	Urban	***All***	Rural	Urban	***All***
Married monogamously	6.07	6.22	***6.1***	7.71	3.9	***6.9***	24.9	27.2	***25.44***	34.66	33.5	***34.5***
Married polygamous	5.75	3.27	***5.05***	7.09	4.47	***6.5***	7.02	4.9	***6.56***	10.16	6.68	***9.54***
Divorced/Separated	6.38	8.36	***6.9***	10.52	12.5	***10.95***	1.52	1.93	***1.61***	3.19	3.46	***3.24***
Widow/Widower	9.97	7.33	***9.2***	15.1	12.4	***14.5***	1.00	0.69	***0.93***	1.44	1.42	***1.44***
Never Married	71.8	74.8	***72.7***	59.6	66.6	***61.1***	65.5	65.3	***65.5***	50.51	54.9	***51.3***

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Explanatory variables

Maddison (2006) and Below et al. (2010) argue that adaptation to climate extremes at a household and farm level is influenced by household and farm level characteristics, infrastructure, and institutional factors. Therefore, we control for households' characteristics such as age of household head, education of household head, asset holding, household size, area of residence, region and off farm employment. Farm characteristics include farm size and land tenure system; institutional factors include access to extension and credit services; and infrastructure includes availability and distance to input and output markets within the Local Council I (LC I), community and climate factors include agro-ecological climate zone[19].

4.3.2 Hypotheses tested

The following hypotheses are made:

[19] Using panel survey data, I categorized Uganda into seven agro ecological climate zones (MAAIF, 1996; World Bank, 1993 and NEMA, 1996). These are presented in Chapter 3-Table 3.2.

i. Higher level of education is believed to be associated with increased access to information on improved technologies and higher productivity. Evidence shows that there is a positive relationship between the level of education of the household head and the adoption of improved agricultural related technologies (Deressa et al., 2008).

ii. Gender of household head: Male-headed households (MHH) are more likely to get information about new technologies and undertake risky businesses than female-headed households (FHH). Specifically, a household headed by a female is less likely to cope by undertaking soil and water conservation measures during shocks because women have limited access to information, land, and other resources due to cultural and social barriers. On the other hand, women are more likely to listen and implement what they have learnt. Here, the signs can go either way.

iii. Age of the head of household is used to capture farming experience. This study hypothesizes that experience increases the probability of adapting to climate change.

iv. Household size: we postulate that households with large families are more likely to adapt to climate change as they have available labour to engage in agricultural activities than households with fewer household sizes. But also the quality of household members in labour force contribution matters.

v. Off farm employment of household head and asset ownership (such as land and livestock) represent wealth. It’s hypothesised that off farm employment and asset ownership can either improve or lower adaptation to climate change. This is because the relative contribution of the two sources of income can differ (low or high) and nature of asset ownership (formal or informal) matters in decision making processes regarding adaptation strategies employed.

vi. Extension services: use of extension services by households is expected to have a positive influence of the response strategies undertaken by households than no access to extension services.

vii. Availability of credit eases the cash constraints and allows farmers to purchase inputs such as fertilizer, improved crop varieties, and irrigation facilities if any. Thus it's expected that we will have a positive relationship between the level of response/coping strategy and availability of credit.

viii. Land tenure system: A more secure land tenure arrangement (formal or informal/customary) is associated with an increase in chances of adaptation to climate change induced shocks. Note that the likelihood of using a specific adaptation strategy to shocks can go either way depending on what is considered secure by female or male headed households.

ix. Availability and distance to nearest market: is used to proxy for availability and ease in accessibility of input/output markets. This should have a positive influence on coping strategies undertaken in response to climate distress events.

x. Agro-ecological climate zones: It is also hypothesized that different households living in different agro-ecological settings use different adaptation methods. This is due to the fact that climatic conditions, soil, and other factors vary across different agro-ecologies; influencing households decisions to respond differently to climate variability and change especially among agricultural households. This goes hand in hand being located in a particular region and area of residence (urban/rural).

Intuitively and guided by economic theory, all the above explanatory variables are assumed to be exogenous in model specification.

4.4 Data transformation and sources

This chapter utilises a two wave panel survey dataset gathered by UBoS. The data is part of the World Bank's Living Standards Measurement Study (LSMS) panels being carried out in some African countries. The panel survey was based on a two-stage stratified random sampling design. In the first stage, Enumeration Areas (EAs) were selected from Uganda's four geographical regions. In the second stage, 10 households were randomly selected from each EA. The first wave was a sample of households that were surveyed in Uganda National Household Survey, 2005/06 (UNHS III). The second wave was a re-tracking of the re-sampled UNHS III households in 2009/10 forming the Uganda National Panel (UNPS) of 2009/10. Specifically, 3,123 households were re-sampled from 7,421 households covered in the UNHS III for tracking in 2009/10. The re-surveyed households were selected out of the same EAs that were covered in UNHS III.[20] The panel in 2009/10 covered 2,975 households out of the 3,123 that were

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[20] The detailed description of the approach can be found in the UNPS 2009/10, Basic Information Document, UBoS (2010).

targeted.[21] The 2,975 households include households that had split-off from the original household sampled. For comparability across panels, 368 split-off households and 41 households with incomplete questionnaires were dropped. Thus, 2,566 original households covered in both surveys and who had complete information were retained for this study.

The UNHS III and the UNPS 2009/10 have some similarities and differences. First, both surveys utilised the same sampling frame based on the population and Housing Census of 2002 though they differed in terms of stratification. The UNHS III used “region” as stratum divided into rural and urban, whereas the UNPS divide the four traditional regions into sub regions as strata. Second, the sampled EAs were visited twice over a period of 12 months to cover the two agricultural cropping seasons. Third, both surveys administered similar questionnaires: the household questionnaire, community questionnaire and the agricultural questionnaire. Specifically, they administered similar individual and household particulars. The difference in the shocks and coping strategy section in the questionnaire arises in the format in which the households’ shocks questions were framed. That is, UNHS III requires households to recall shocks that occurred 5 years prior to the survey and the UNPS recall period is 12 months prior to the survey. For simplicity of analysis, we assume that a household has experienced a shock one way or another irrespective of the recall period. In addition, the differences in recall

[21] As pointed out in the UNPS background report, the failure to cover the difference was because some households had shifted to unknown locations that could not be found, some households refused whereas others had disintegrated among others.

periods in the survey data can potentially bias our estimates. However, addressing the bias is beyond the scope of this study. To capture Uganda's climate indicators, sampled households in this study where categorised on the basis of agro ecological zones. Sampling weights are used throughout the analysis to account for under and over sampling in EAs, making the survey data nationally representative. For emphasis, analysis is at household level unless otherwise stated.

4.5 Results and discussion

4.5.1 Descriptive analysis

Variable definition and summary statistics are presented in Table 4.2. About 22 percent of the households reside in urban areas (Table 4.2). The average age of the household head is 44.4 years with 71.8 percent of the households headed by males. The data indicates that Uganda still has households that had heads of 13 years (child headed homes). The sample had more households located in the Central region with an average distribution of 30 percent and other regions had a more even distribution of sampled households. About 26.3 percent of the household heads had employment off the farm. The average farm size is four acres where in regard to tenure, male headed households (MHHs) have a larger share of their land holdings customary (73.2 percent) than formal (71 percent) while the converse holds for female headed households (FHHs) (result not shown in Table 4.2). The average household size is five. Twenty three percent of MHHs and only 8 percent of FHHs had post primary education. About 38.8 percent of the households were located in the Banana/coffee agro-ecology with Teso and Pastoral agro-ecologies having the least number of households, four and 5.9 percent respectively. On average, the nearest market within the LC1 area is 2km. Of the 22 percent of the households who had applied for loans, only 34 percent of the loans were approved. Four percent of the households indicate to have been visited on average three times by an agricultural extension worker during two cropping seasons. The findings here concur with national statistics (UNHS report, 2010).

Table 4.2: Variable description and descriptive statistics

Variable name	Variable label	Obs	Mean	Std. Dev.	Min	Max
Sexhead	Gender of household head, 1 if male	5173	0.7189	0.4496	0	1
Sexspouse	Gender of household spouse, 1 if male	3480	0.0543	0.2267	0	1
Agehead	Age of household head	5169	44.3819	15.1208	13	100
Agespouse	Age of spouse	3423	35.8596	12.1304	15	98
Male head education	Primary	3599	0.7697	0.4211	0	1
	Secondary	3599	0.1987	0.3991	0	1
	Tertiary	3599	0.0317	0.1752	0	1
Female head education	Primary	3482	0.9156	0.2781	0	1
	Secondary	3482	0.0796	0.2706	0	1
	Tertiary	3482	0.0049	0.0697	0	1
Region	Central	5173	0.3027	0.4595	0	1
	East	5173	0.2314	0.4218	0	1
	North	5173	0.2414	0.4280	0	1
	West	5173	0.2244	0.4172	0	1
Offfarmhead	Off farm employment for HH head	5146	0.2627	0.4402	0	1
Offfarmspouse	Off farm employment for spouse	4680	0.1169	0.3213	0	1
Credit	Applied for a loan in the last 12 months, 1 if yes	5165	0.2170	0.4123	0	1
Loanstatus	1 if loan was fully approved	2190	0.3379	0.4731	0	1
Urban	1 if urban	5173	0.2281	0.4197	0	1
Hsize	Household size	5170	5.5851	2.9343	1	29
Copdrought	Coping strategy for drought	2026	3.7671	1.2501	1	5
Copfloods	Coping strategy for floods/hailstorms	366	3.4836	1.2599	1	5
Coppests	Coping strategy for crop pests	300	3.4333	1.0876	1	5
Coplepidemic	Coping strategy for livestock epidemics	140	3.2643	0.9936	1	5

Bananacoffee	Agro-ecological climate zone	5172	0.3877	0.4873	0	1
Bananamilletcotton	Agro-ecological climate zone	5172	0.0889	0.2847	0	1
Montane	Agro-ecological climate zone	5172	0.2109	0.4080	0	1
Teso	Agro-ecological climate zone	5172	0.0443	0.2057	0	1
Northern	Agro-ecological climate zone	5172	0.1164	0.3207	0	1
Pastoral	Agro-ecological climate zone	5172	0.0588	0.2352	0	1
WestNile	Agro-ecological climate zone	5172	0.0930	0.2905	0	1
Farmsize	Parcel size in acres	3711	3.9116	17.2480	0	600
Tenures	Tenure system, 1 if formal	3677	0.6239	0.4845	0	1
Extension	If visited by an extension worker, 1 if yes	3346	0.0451	0.2076	0	1
Textension	No. of times the extension worker has visited	374	3.7807	4.9997	1	48
InputmktlcI	Availability of input market in LC1, 1 if yes	4752	0.4112	0.4921	0	1
Distinmkt	Distance to input market	4663	2.1995	3.8279	0	32

Notes: For coping Strategies; we categorised borrowing (1), labour supply (2), technology (3), savings (4) and reducing consumption (5)

Source: Author's calculations based on the 2005/06 and 2009/10 panel

4.5.2 Chi square test between gender of household head and adaptation choices

We test for two attributes, gender of household head and choices of coping strategies employed. The rationale here is that the decision to choose between adaptation strategies when faced with different climate disasters differs and these choices depend on the gender of the decision maker of the household-in other words, the household head as per the survey definition of a head. To test this, we apply the chi-square independence test. The null hypothesis is that the choice of adaptation strategies to a covariate shock is independent of the gender of household head. Results are presented below:

Coping drought: Pearson chi2(4) = 5.0e+03 Pr = 0.000
Coping floods: Pearson chi2(4) = 4.8e+03 Pr = 0.000
Coping pests: Pearson chi2(4) = 7.6e+03 Pr = 0.000
Coping livestock epidemics: Pearson chi2(4) = 6.9e+03 Pr = 0.000

Based on the results above, we reject all the null hypotheses that choices of adaptation strategies to shocks are independent of the gender of the household head. Thus, we proceed with identifying the frequency of shocks reported by households and the choice of adaptation strategies employed to address another objective of this chapter.

4.5.3 Types and frequency of climate shocks reported by households

The surveys capture information on both covariate and idiosyncratic shocks. However, in this study, only issues related to covariate shocks are analysed. The most common types of shocks are drought related (Table 4.3). Households that experienced droughts increased between the survey periods. For other shocks, households' experience a decline from 2005/06 to 2009/10.The difference in experiences/frequency of shocks reported is attributed to the recall period.

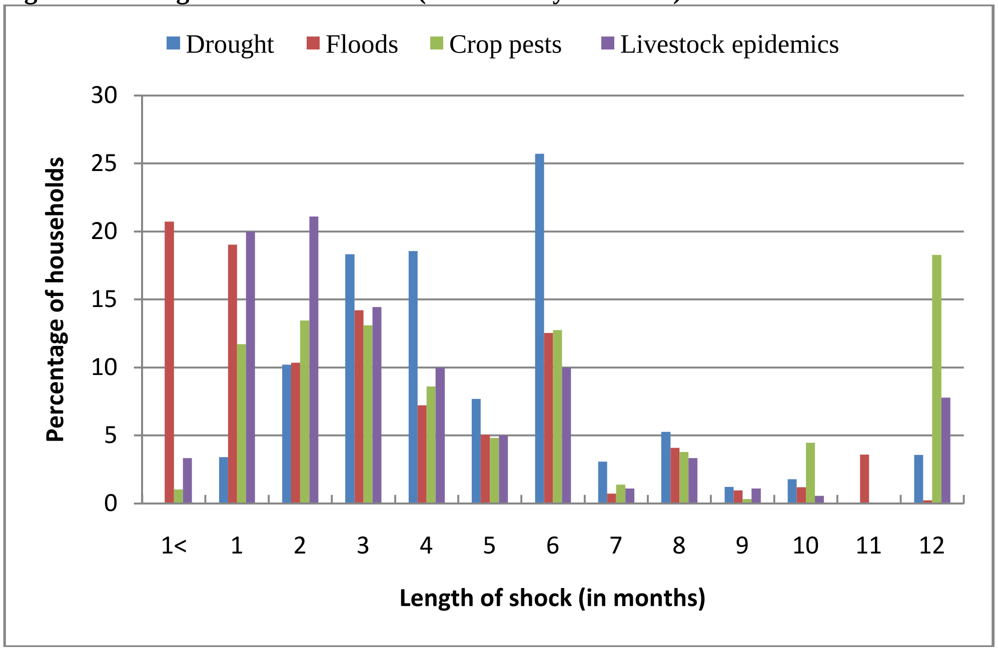
Table 4.3: Number of sample households that experienced and adapted to shocks

Type of shock	**2005/06** No. of households (based on 5 year recall)	**2009/10** No. of households (based on 1 year recall)
Drought	1,121	1,235
	(40.69)	(46.09)
Floods	393	51
	(14.66)	(1.98)
Crop pests	274	125
	(10.10)	(4.98)
Livestock epidemics	173	78
	(6.07)	(3.22)
Panel sample	***2,566***	***2,566***

Notes: In the parenthesis are percentages based on the weighted sample
Source: Author's calculations based on the 2005/06 and 2009/10 panel

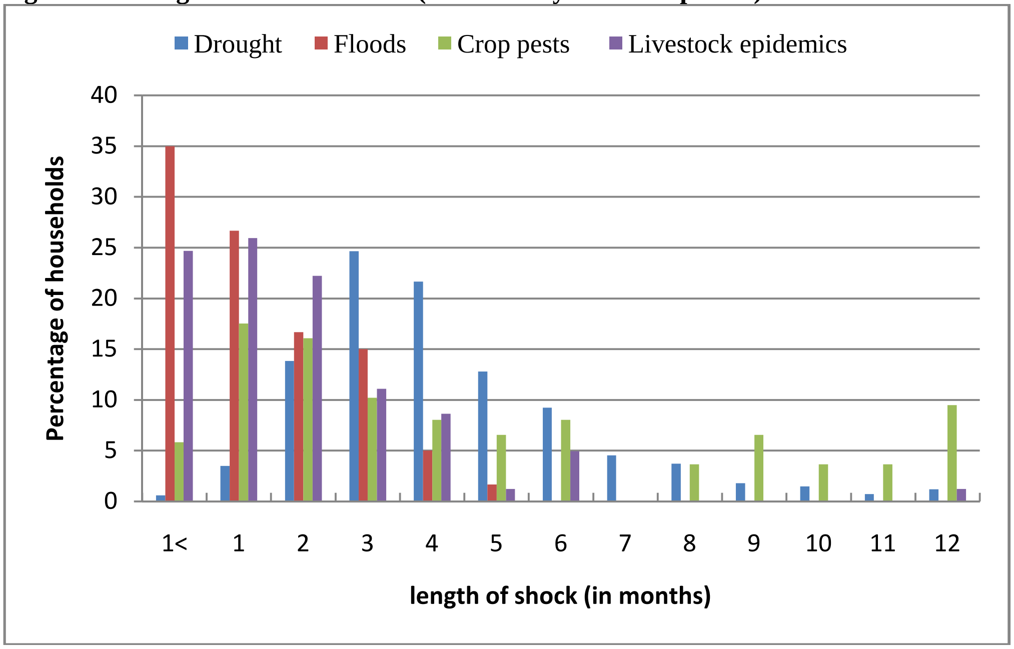
Figures 4.3 and 4.4 show the duration of shocks for each year of survey (based on different recall periods).

Figure 4.3: Length of shock-2005/06 (based on 5 year recall)



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 4.4: Length of shock-2009/10 (based on 1 year recall period)



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Regardless of the recall period, marginal differences are noted in the length of shocks that the sampled households report between the survey periods. Droughts and crop pests appear to be more persistence throughout the year. The average length of droughts is four months and crop pests five months. Floods and livestock epidemics are also common and persist but severe episodes last only for a short time (Figure 4.3 and 4.4). It is interesting to note that crop pests and livestock epidemics persist more in periods of drought. The persistence in shocks reported are an indication of a changing climate and support evidence on how climate change will manifest itself (IPCC, 2007; 2012).

4.5.4 Gender of household head and choice of coping mechanisms

Table 4.4 presents cross tabulations by gender of the household head (decision maker), area of residence and year of survey. In sum, FHHs increased from 27.2 percent in 2005/06 to 28.5 percent in 2009/10. There were more FHHs in rural areas than urban with similar observations for MHHs. Regional variations show that 2005/06 had more FHHs living in the Central and Northern parts of the country. In 2009/10, FHHs and MHHs in central region declined, other regions show increases. The trend has been attributed to the Northern Uganda Rehabilitation Programme (NURP) embedded in the Peace Recovery and Development Plan (PRDP) that has resettled over 85 percent of the Internally Displaced Persons (IDP).[22]

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[22]During the 22 years of conflict, people within and close vicinity of Northern Uganda fled to neighboring towns and the city. For further details see Adong (2011) and UNHS 2009/10 report (UBoS, 2010).

Table 4.4: Gender of household head by residence and region (% of total)

	2005/06			2009/10		
	Female Head	Male Head	Uganda	Female Head	Male Head	Uganda
Area of residence						
Rural	20.5	57.5	78.0	22.9	58.9	81.8
Urban	6.8	15.2	22.0	5.6	12.7	18.2
Region						
Central	11.0	25.5	36.5	9.8	24.0	33.8
Eastern	5.2	15.1	20.3	6.4	16.1	22.5
Northern	5.8	13.0	18.8	6.3	12.1	18.4
Western	5.3	19.1	24.4	5.9	19.4	25.3

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table 4.5 presents coping strategies by gender of the household head and covariate shocks identified by year of survey. The choice of adaptation strategies varied between survey periods with a higher variability in MHHs. The analysis reveals that in both survey periods, FHHs consistently scaled back consumption as a coping strategy during drought. Initially, MHHs increasingly relied on savings but reduced food intake in the second round of the survey during drought. Both male and female headed households utilise savings and reduce consumption in this order during floods/hailstorms. For both FHHs and MHHs, use of technology was high in 2005/06 while scaling back consumption was higher in 2009/10 as coping strategies to crop pests and disease attacks. Expanding labour supply is the third most commonly employed choice of adaptation strategy in response to drought, floods and pest attacks for all households. But during livestock epidemics, MHHs relied mainly on their savings and FHHs supplied more labour. Borrowing is the least applied adaptation strategy irrespective of gender where FHHs especially did not access any formal or informal credit institutions during livestock epidemics across the survey periods.

Table 4.5: Coping mechanisms by gender of household head and covariate shock (% of totals)

	Drought			Floods			Pests			Livestock Epidemic		
2005/06												
Coping Strategy	Female	Male	All	Female	Male	All	Female	Male	All	Female	Male	All
Borrowing	0.8	3.0	3.8	2.1	3.9	6.0	0.7	0.4	1.1	0.0	2.2	2.2
Labour supply	7.4	17.3	24.7	5.0	18.5	23.5	5.7	13.7	19.4	11.0	24.7	35.6
Technology	1.2	3.2	4.4	2.7	5.7	8.4	6.8	33.5	40.3	2.6	8.6	11.2
Savings	7.1	31.5	38.6	5.7	32.8	38.5	5.0	16.1	21.0	10.9	37.0	47.8
Reduce consumption	8.6	19.9	28.5	2.9	20.6	23.5	5.6	12.7	18.2	1.2	1.9	3.1
2009/10												
	Drought			Floods			Pests			Livestock Epidemic		
	Female	Male	All	Female	Male	All	Female	Male	All	Female	Male	All
Borrowing	0.7	1.1	1.8	0.0	0.0	0.0	0.0	4.5	4.5	0.0	0.0	0.0
Labour supply	5.0	15.0	20.0	4.1	21.3	25.4	5.0	4.8	9.8	0.0	9.9	9.9
Technology	1.4	3.8	5.2	0.0	5.4	5.4	7.6	13.7	21.2	0.0	6.7	6.7
Savings	7.7	17.7	25.4	3.3	14.8	18.0	2.7	24.2	26.9	8.3	65.7	74.1
Reduce consumption	14.3	33.3	47.5	22.0	29.1	51.1	11.6	25.9	37.6	5.0	4.4	9.4

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Trends of adaptation choices here are similar to those found in Pakistan by Heltberg and Lund (2009) and in Uganda by Hisali et al. (2011). But what is important to note here, is that households coping mechanisms are not consistent across survey periods for many of the shocks experienced by households other than livestock epidemics. Our finding of reducing food intake for households who had a female decision maker during drought is not surprising. Pankhurst and Bevan (2004) and Muhanguzi et al. (2012) argue that if there is a shortage of food at home during drought and famine, the woman scales down the number of meals per day giving priority to her children while the man can go eat elsewhere, work locally or migrate.

Hisali et al. (2011) argue that the limited use of borrowing as an adaptation choice by households could partly be due to the stringent repayment conditions coupled with the relatively high interest rates on the Ugandan financial market. But, it could also be that the types of coping strategies being undertaken do not require households to necessarily borrow as they rely on “physical savings” as a buffer to smoothen their consumption paths and livelihood amidst uncertainty (Deressa et al., 2008). It can be argued that female headed homes have limited access to social networks and do not have tangible assets such as land to use as collateral when accessing loans (Agarwal, 1997; Alston, 2006; Nabikolo et al., 2012). To sum up, many of the coping strategies undertaken are informal, insufficient and ineffective for covariate shocks whose impacts are severe. They compromise welfare, increase child labour and recovery from shock is slow and often incomplete before another shock occurs.

Additional results of the bivariate and multivariate relationships between choice of adaptation strategies and region, credit access and extension services are presented in Appendix B: Tables B.1, B.2 and B.3. Differences in choices of adaptation strategies to covariate shocks across regions are noted as some distress events such as livestock epidemics and floods are region specific. While, access to credit and extension services seem not to have played a key role in the coping mechanisms to shocks employed by households across gender.

4.5.5 Econometric results and discussion

In this subsection, Tables 4.6 to 4.9 present the results of the pooled MNL model (Equation 4.6) of factors determining choice of adaptation strategies based on the gender of the household head and the four covariate shocks; i.e., drought, floods, crop pests and diseases attacks, and livestock epidemics. Each equation constructed is based on different factors that determine the choice of coping strategies for a covariate shock for male and female headed households.[23] The corresponding relative risk ratios (RRRs) are discussed in this chapter while marginal effects are presented in Appendix B: Tables B.4-B.7. Throughout this chapter, column (1) results are for FHHs and column (2) results are for MHHs. In addition, annexed are the Hausman-McFadden tests for IIA (Appendix B: Tables B.8-B.11) and the predictive probabilities for each model estimated are also discussed (Figures 4.5-4.12). Thus:

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[23]Empirical analysis included only variables identified with the ability to achieve convergence and give good predictions. Estimated equations that produce the best fit are reported. Comparability between different model estimates is not possible.

Factors determining choice of coping strategies during drought occurrences

The Hausman test validates the IIA assumption (Appendix B: Table B.8). Factors that influence the choice of coping strategies in response to drought for FHHs and MHHs are presented in Table 4.6 (RRRs) and the marginal effects are in Appendix B: Table B.4. These are:

Age of household head: In FHHs, age of household head reduces the relative risk of expanding labour supply as opposed to reducing consumption by 0.979 times as a coping strategy in response to drought. This reflects the relative vulnerability FHHs face in assessing their social networks.

Size of the household in FHHs reduces the relative risk of increasing labour supply relative to reducing consumption by 0.91 times while increasing the relative risk of utilising savings relative to reducing consumption during drought. Access to credit in FHHs reduces the odds of utilising savings as opposed to reducing consumption during drought.

Extension services: Here, FHHs are less likely to borrow relative to reducing consumption and are more likely to employ use of technology by 4.19 times than reduce consumption while MHHs are more likely to increase use of savings as opposed to reducing consumption by 2.39 times.

Land tenure system: In Uganda, customary land holding for women is less secure compared to formal land holding due to social and cultural construction of gender roles in land ownership (Republic of Uganda, 2011). Such that results show that with a less secure land tenure system arrangement, the odds of utilising of savings relative to reducing consumption are low by 0.499 times. But again, FHHs are more likely to supply more labour than reduce consumption in drought conditions. While in MHHs, tenure system is associated with an increase in the chances of adapting to drought through increased borrowing, expanding labour supply and use of savings by 2.66 times, 2.45 times and 2.72 times respectively relative to scaling back consumption.

Regional setting: Relative to the Central region, for MHHs in the Western region, the odds of increasing labour supply, use of technology and savings relative to reducing consumption reduces by 0.21 times, 0.28 times and 0.45 times respectively during drought. MHHs in the Eastern region are less likely to utilise savings relative to reducing consumption (by 0.285 times) and also more likely to use technology (by 2.87 times) than reduce consumption. On the other hand, FHHs in the Eastern region are less likely to use technology relative to reducing consumption. Here, it can be argued that the endowment effect is stronger in households in the Central region as a result of the region being proximity to Kampala Capital City.

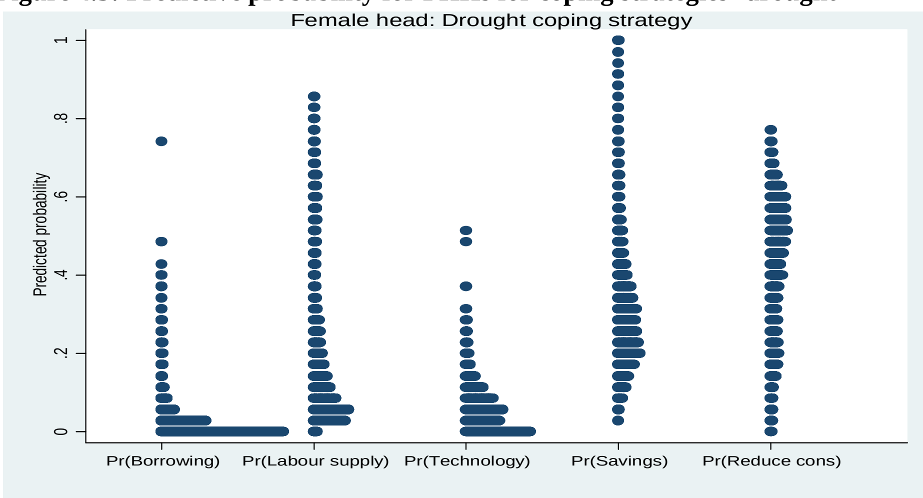
Off farm employment of head: Access to job opportunities off the farm increases the relative risk of adapting to drought through expansion of labour supply by 2.13times as opposed to reducing consumption in MHHs. This supports the positive effect that increased access to employment opportunities (formal or otherwise) has on credit worthiness hence increasing chances of increasing labour supply as individuals social networks widen (Gbetibouo, 2009; Below et al., 2010).

Distance to market: This is used to proxy for the availability and ease in access to in- and output markets. For FHHs, this increases the relative risk of borrowing by 1.26 times and labour supply by 1.17 times relative to reducing consumption. On the other hand, for MHHs during drought, distance to markets increases the odds of borrowing by 1.11 times and using savings by 1.08 times relative to reducing consumption during drought.

Agro-ecological climate zone: FHHs in the West-Nile zone are more likely to increase labour supply (by 11.15 times) and use savings (by 3.63 times) relative to reducing consumption and those in the Pastoral system are more likely to also increase labour supply. FHHs in Montane zone are more likely to use savings as opposed to reducing consumption. Furthermore, FHHs in the Banana/Millet/Cotton zone are less likely to borrow and use technology relative to reducing consumption and those located in the Teso system are also less likely to borrow but more likely to increase labour supply as opposed to reducing consumption in drought conditions. MHHs in the West-Nile, Banana/Millet/Cotton and Northern systems are less likely to borrow while those in Pastoral systems are likely to increase borrowing relative to reducing consumption during drought. In addition, MHHs in the West-Nile and Northern zones are less likely to use savings relative to reducing consumption, and those in the Northern zone are also less likely to increase labour supply as opposed to reducing consumption.

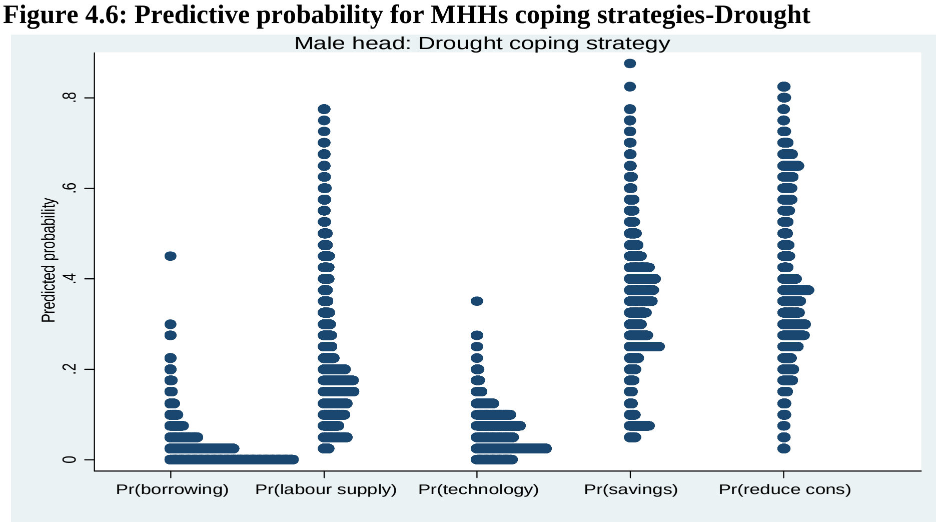
Predictive probabilities confirm findings from the descriptive analysis indicating reducing consumption, using savings and increasing labour supply as most common adaptation strategies for FHHs and MHHs amidst droughts (Figure 4.5 and 4.6).

Figure 4.5: Predictive probability for FHHs for coping strategies- drought



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 4.6: Predictive probability for MHHs coping strategies-Drought



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table 4.6: Pooled MNL estimates by gender for factors determining coping strategies against drought (RRRs)

	(1) FHHs				(2) MHHs			
Coping-drought	Borrowing	Labour supply	Technology	Use savings	Borrowing	Labour supply	Technology	Use savings
Age head	0.958	0.979*	0.995	0.997	1.017	0.993	0.987	0.997
	(0.029)	(0.012)	(0.016)	(0.010)	(0.0116)	(0.0064)	(0.011)	(0.0057)
Household size	0.943	0.905**	1.169	1.159**	1.001	0.944	1.083	0.983
	(0.107)	(0.044)	(0.125)	(0.071)	(0.081)	(0.04)	(0.065)	(0.028)
Urban					2.324	1.970	1.793	1.299
					(2.2236)	(0.927)	(1.177)	(0.633)
Access to credit	2.277	1.750	0.517	0.388**	1.379	0.932	0.911	1.278
	(2.648)	(0.808)	(0.484)	(0.165)	(0.8718)	(0.222)	(0.341)	(0.279)
Region								
East	2.710	0.651	4.09e-10***	1.236	0.391	0.563	2.867*	0.285**
	(3.619)	(0.514)	(2.53e-10)	(0.854)	(0.407)	(0.262)	(1.682)	(0.124)
West					1.234	0.206***	0.282*	0.449*
					(1.020)	(0.089)	(0.188)	(0.203)
Land tenure	0.445	2.729*	0.716	0.499*	2.662*	2.450**	0.668	2.720***
	(0.381)	(1.528)	(0.510)	(0.192)	(1.469)	(0.829)	(0.358)	(0.799)
Off farm employ’t head					1.806	2.128***	0.753	1.071
					(0.889)	(0.485)	(0.298)	(0.208)
Distance to market	1.259*	1.169**	0.954	1.035	1.106*	1.049	0.995	1.078**
	(0.170)	(0.073)	(0.065)	(0.059)	(0.059)	(0.041)	(0.062)	(0.038)
Extension services	6.63e-10***	4.112	4.191*	1.303	3.411	0.432	0.307	2.389**
	(5.65e-10)	(4.460)	(3.490)	(0.890)	(2.582)	(0.233)	(0.320)	(0.937)
Agro-ecologies								
WestNile	2.463	11.154***	0.678	3.627**	2.71e-10***	1.699	0.842	0.331**
	(2.703)	(5.190)	(0.799)	(2.291)	(2.19e-10)	(0.697)	(0.538)	(0.146)
Teso	3.97e-10***	17.574**	1.092	3.712				
	(5.68e-10)	(16.444)	(1.202)	(3.680)				
Pastoral	1.096	2.192*	0.629	1.014	3.436*	1.707	3.12e-10***	0.797
	(1.312)	(1.032)	(0.686)	(0.681)	(2.586)	(0.944)	(1.46e-10)	(0.417)
Montane	0.256	0.549	2.177	2.087*	2.289	0.788	0.483	1.006
	(0.247)	(0.375)	(1.554)	(0.899)	(1.393)	(0.327)	(0.254)	(0.393)
Banana/millet/cotton	2.09e-10***	2.241	1.26e-09***	2.451	4.57e-10***	0.596	0.474	1.172

	(3.03e-10)	(2.469)	(2.00e-09)	(2.709)	(3.02e-10)	(0.351)	(0.310)	(0.517)
Northern					0.083*	0.226***	0.808	0.039***
					(0.1095)	(0.092)	(0.4099)	(0.017)
Diagnostics								
Un-weighted sample	346				1,094			
Weighted sample	431,772				1,338,245			
Pseudo R^2	0.1640				0.1354			
Prob>chi^2	0.0000				0.0000			
Log likelihood	-457255.97				-1512397.80			
Base outcome	Reduce consumption				Reduce consumption			

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$.

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Factors determining choice of coping strategies during floods

Predictors of different adaptation strategies to floods for FHHs and MHHs are presented in Table 4.7 (the Hausman test validates the IIA assumptions –Appendix B: Table B.9) and the corresponding marginal effects are presented in Appendix B: Table B.5. These are:

First, for FHHs, age of household head leads to the odd of expanding labour supply as opposed to reducing consumption increase by 1.068 times. Second, a breakdown of regions indicate that the relative risk of increasing labour supply and use of savings relative to reducing consumption reduces by 0.047 times and 0.18 times respectively for FHHs located in the Eastern part of Uganda. While, MHHs in the Eastern region are less likely to resort to technology use (0.197 times) and reducing consumption (0.26 times) relative to relying on savings. Similarly, MHHs located in the Western region are less likely to expand labour supply and reduce consumption relative to savings when floods occur. Third, with regard to off farm employment for the household head, this indicates that the odd of providing labour supply relative to using saving increases by 2.31 times in MHHs. Heltberg and Lund (2009) asserts that employment opportunities help widen safety nets available to households thus enabling them maintain their consumption needs when calamities arise.

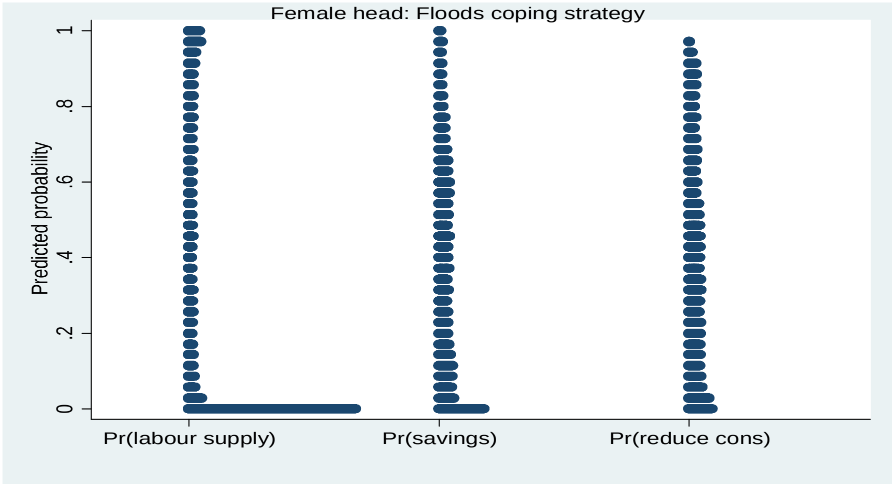
Fourth, distance and accessibility to markets for MHHs reduce the relative odds of minimising consumption and increasing labour supply as opposed to savings by 0.92

times and 0.93 times respectively. FHHs on the other hand are more likely to expand labour supply relative to reducing consumption in response to floods. According to Below et al. (2010) and Hisali et al.(2011), ease in accessing markets within and outside sub counties help smoothen consumption paths as households easily sell assets (such as previous period harvest/crop yield).

Lastly, the odd of increasing savings as opposed to reducing consumption is low for FHHs in the Banana/Millet/Cotton agro ecological zone amidst floods and similarly, the odd of reducing consumption relative to savings is higher in MHHs (7.22 times). In Banana/Coffee systems, the relative risk of supplying more labour relative to reducing consumption is low for FHHs and the likelihood that MHHs in the same zone will expand labour supply relative to use of savings is low. Furthermore, the relative risk of increasing technology use relative to savings in MHHs located in the Teso agro-ecology becomes higher by 27.47 times. FHHs in the Montane zone are less likely to expand labour supply relative to reducing consumption and MHHs are more likely to reduce consumption relative to savings. Simply put, both FHHs and MHHs in Montane areas reduce consumption as a coping strategy during floods.

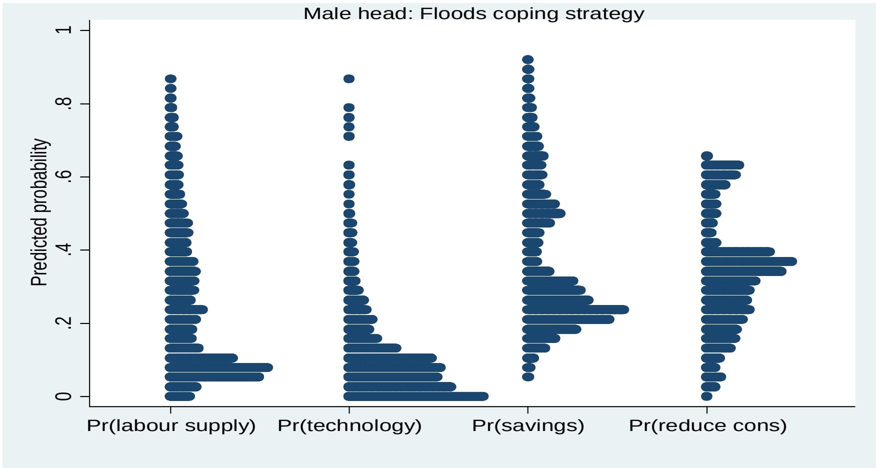
In line with the descriptive statistics, the predictive probability of FHHs for coping strategies against floods show no discernible pattern in use of reducing consumption, labour supply and savings (Figure 4.7). And, predictions indicate persistence in use of labour supply and savings as coping mechanisms in the event of floods occurring for MHH (Figure 4.8).

Figure 4.7: Predictive probability of FHHs for coping strategies against floods



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 4.8: Predictive probability for MHHs coping strategies-Floods



Source: Author's calculations based on the 2005/06 and 2009/10 panel

According to meteorological data, areas most hit by floods/hailstorms in Uganda are located in the parts of Northern, Western and Eastern regions. Differences in factors determining coping strategies in agro ecological zones and regions noted here support meteorological information. Areas in the Northern, Teso and some parts of Montane agro-ecologies receive emergency food aid (which is untimely and unsustainable) during floods (see Republic of Uganda, 2010).

Table 4.7: Pooled MNL estimates by gender for factors determining coping strategies against floods

	(1) FHHs		(2) MHHs		
Coping-floods	Labour supply	Use savings	Labour supply	Technology	Reduce consumption
Age head	1.0678*	0.9686	0.9935	1.0192	0.9992
	(0.0426)	(0.02995)	(0.01434)	(0.02008)	(0.01118)
Household size	1.0961	0.8824			
	(0.2162)	(0.18864)			
Urban	29.0338	0.6649	2.1223	2.5402	0.46667
	(81.0817)	(0.9637)	(0.8419)	(2.9533)	(0.36884)
Region					
East	0.04728**	0.1796*	0.62798	0.20244*	0.26323**
	(0.0563)	(0.1748)	(0.92204)	(0.18042)	(0.16692)
West			0.04979*	0.16908	0.15348**
			(0.7797)	(0.23009)	(0.11704)
Off farm employ't head	1.3869	0.9439	2.3103*	0.47215	0.9316
	(1.4567)	(1.1021)	(1.0044)	(0.35975)	(0.34867)
Distance to market	1.6170**	1.2829	0.9268*	1.04211	0.9162**
	(0.3289)	(0.2231)	(0.04228)	(0.07987)	(0.03493)
Agro-ecologies					
Banana/millet/cotton	3.9552	1.10e-09***	1.8143	8.9379	7.2168*
	(5.9661)	(1.62e-09)	(3.1872)	(12.3654)	(7.8707)
Banana/coffee	1.80e-11***	1.1916	0.18308	1.5946	3.2237
	(4.95e-11)	(1.6122)	(0.21579)	(1.7508)	(2.9146)
Northern	3.6610	1.0504	1.0354	2.3329	2.2131
	(6.0456)	(2.7192)	(0.81164)	(2.7503)	(1.8094)
Teso			2.8998	27.4702**	1.6593
			(4.7676)	(36.0715)	(2.3235)
Montane	0.00923*	0.8186	2.5982	0.36714	6.1686*
	(0.02278)	(0.718)	(4.4488)	(0.70699)	(6.7006)
Pastoral			1.08596	1.40756	3.6149
			(1.4047)	(2.0932)	(3.9223)
Diagnostics					
Un weighted sample	54		274		
Weighted sample	51,324		223,039		
Pseudo R^2	0.4063		0.1473		
Prob>ch^2	0.0000		0.0000		
Log likelihood	-33074.16		-239891.76		
Base outcome	Reduce consumption		Use of savings		

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Factors determining coping strategies to crop pests

Results (RRRs) for FHHs and MHHs presented in Table 4.8 and the Hausman test supports the null of IIA since probability value (p>chi2) is 1.00 (Appendix B: Table B.10). The marginal effects after estimation of the MNL are presented in Appendix B: Table B.6. Thus, the variables that determine the choice of adaptation strategies to crop pests are:

For FHHs, age of the household head reduces the odds of increasing supply of labour and savings as opposed to use of technology and for MHHs, the relative risk of increasing labour supply, use of savings and cutting back consumption relative to use of technology increases by 1.031 times, 1.029 times and 1.048 times respectively. Household size can be either a curse or a blessing depending on the quality of the labour force of household members either in ability to access better paying jobs, age, education and health. Findings indicate that the odds of expanding labour supply are lower by 0.754 times in FHHs relative to use of technology.

Table 4.8: Pooled MNL estimates by gender for factors determining coping strategies against crop pests (RRRs)

	(1) FHHs			(2) MHHS		
Coping-crop pests	Labour supply	Use savings	Reduce consumption	Labour supply	Use savings	Reduce consumption
Age head	0.9397*	0.9590**	1.0017	1.0309*	1.0293**	1.0477**
	(0.0294)	(0.02014)	(0.02804)	(0.01788)	(0.0119)	(0.01777)
Household size	1.2111	1.04761	0.77306	0.7535**	0.8475	0.95851
	(0.288)	(0.1396)	(0.1872)	(0.07413)	(0.0962)	(0.07082)
Access to credit				2.9499	4.8943	1.3334
				(4.1808)	(6.6056)	(1.27797)
Urban	1.0248	7.69189*	0.91404	3.17705	7.7283**	14.2699***
	(1.2039)	(9.5912)	(2.1607)	(2.4010)	(5.0588)	(10.3768)
Availability of market	11.1179	0.89256	23.4483**	1.3932	1.3282	8.0647**
	(18.769)	(0.7806)	(24.6699)	(1.4849)	(1.0867)	(6.9051)
Distance to market	1.3952*	0.90745	1.37139**			
	(0.2645)	(0.14914)	(0.1909)			
Agro-ecologies						
Teso	0.3837	0.19958	4.44e-10***	1.2376	0.26792	0.55457
	(0.723)	(0.3662)	(8.65e-10)	(0.9128)	(0.2607)	(0.6104)
Northern	0.84172	1.68505	0.1844	1.6846	1.1528	0.8811
	(0.9686)	(2.6203)	(0.2295)	(0.9960)	(0.7335)	(0.6346)
WestNile				0.85425	2.4e-10***	0.49044
				(0.7651)	(1.96e-10)	(0.6543)
Banana/millet/cotto	1.26***	0.34099	13.0354	0.63307	0.4894	0.1835
	(2.04)	(0.4660)	(32.4185)	(0.4931)	(0.3706)	(0.2228)
Banana/coffee	0.0603*	6.03798	1.8496	0.1303**	0.4565	0.2564**
	(0.0981)	(0.0769)	(1.72547)	(0.095)	(0.2671)	(0.15667)
Diagnostics						
Un-weighted sample	68			211		
Weighted sample	71,183			196,786		
Pseudo R^2	0.2756			0.150		
Prob>chi^2	0.0000			0.0000		
Log likelihood	-69970.09			-220849.44		
Base outcome	Technology			Technology		

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

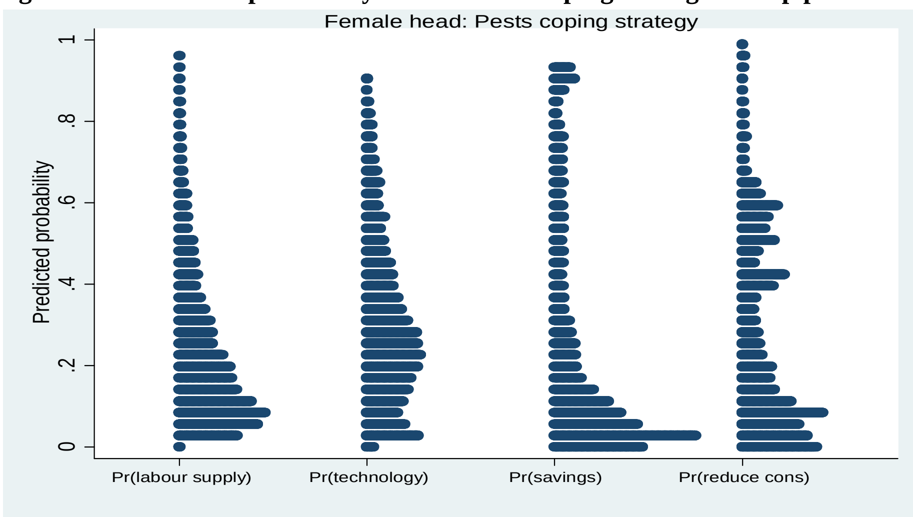
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Relative to households in urban areas, being in the rural areas increases the relative risk of relying on savings (e.g. last season harvests) more than use of technology for FHHs (by 7.69 times) and MHHs (by 7.73 times). In addition, MHHs in rural areas are more likely to further scale back consumption needs by 14.27 times relative to use of technology during pest attacks. Availability and distance to market show that for FHHs and MHHs, availability of a market within the LC I area increases the relative risk of reducing consumption relative to adoption of technology by 23.45 times and 8.065 times respectively. While, actual distance to the available market implies that FHHs are more likely to expand labour supply (1.395 times) and further cut on consumption needs by 1.371 times relative to use of technology. As discussed in Deressa et al. (2008), reduction in consumption for many households in relation to markets is due to the sale of the buffer stock in nearby markets for income to purchase other household needs.

And lastly, with regard to agro-ecological zones, FHHs in the Teso system are less likely to reduce consumption and MHHs in the West-Nile system are also less likely to increase use of savings relative to technology use. But FHHs in the Banana/Millet/Cotton systems will likely expand labour supply by 1.26 times while those in the Banana/Coffee systems are likely to reduce labour supply relative to use of technology during pests and disease outbreaks. Furthermore, the odds of MHHs in the Banana/Coffee region expanding labour supply and reducing consumption relative to use of technology become even lower.

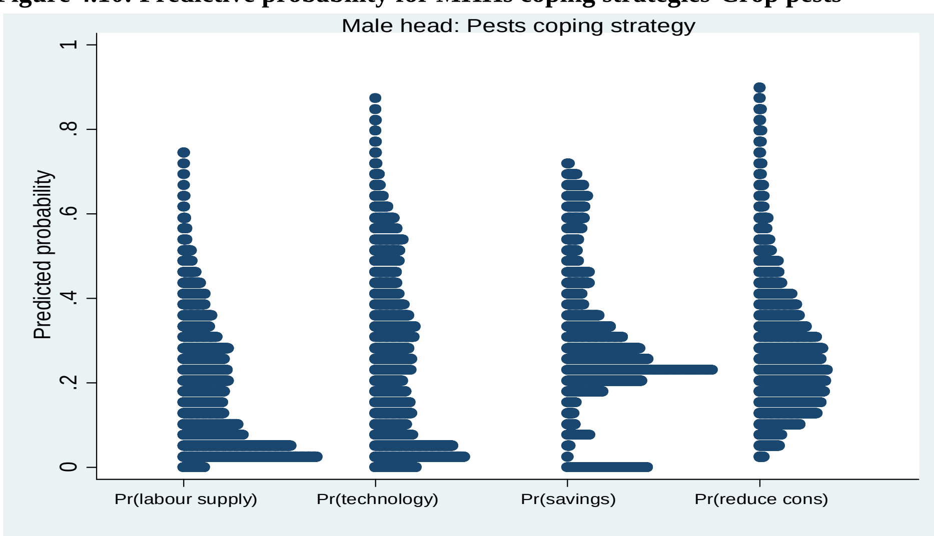
Predictions show a mixed pattern in use of coping strategies such as reducing consumption, labour supply and using savings when crop pests and disease exacerbate in FHHs (Figure 4.9). While predictions show use of technology and reducing consumption (in this order), as the most commonly used forms of coping mechanisms undertaken by MHHs during crop pest and disease outbreaks (Figure 4.10).

Figure 4.9: Predictive probability for FHHs for coping strategies- crop pests



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 4.10: Predictive probability for MHHs coping strategies-Crop pests



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Factors determining coping strategies to livestock epidemics

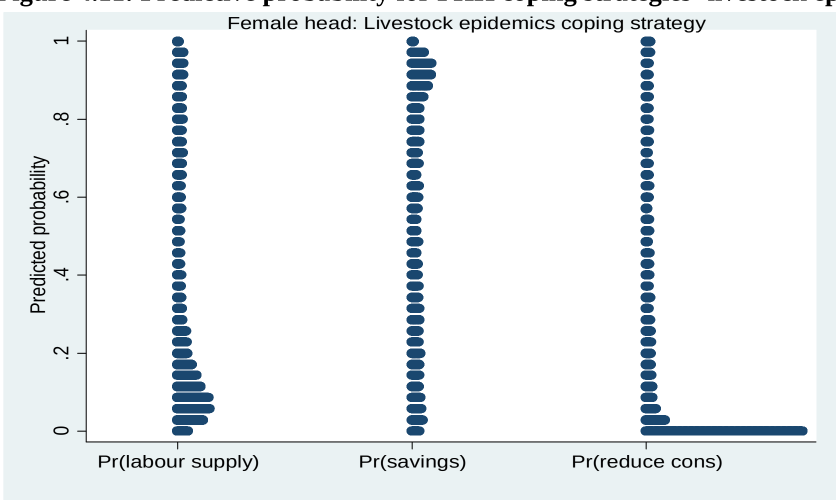
Table 4.9 presents results (RRRs) of factors that ascertain choice of adaptation strategies to livestock epidemics for FHHs[24] and MHHs, marginal effects are also presented in Appendix B: Table B.7 and the Hausman tests indicate a fulfilment of the IIA assumptions (Appendix B: Table B.11). These include:

During livestock epidemics, for FHHs, age of household head increases the relative risk of reducing food intake as opposed to use of savings by 1.19 times. The size of the household lower the likelihood of expanding labour supply relative to savings for FHHs and MHHs. Customary land tenure system reduces the odds of increasing use of technology and labour supply relative to savings in MHHs. Regional variations show an increase in the relative risk of MHHs in the Eastern region increasing use of technology relative to savings by 19.88 times. Relative to the Central region, MHHs and FHHs in the Northern region more likely to increase labour supply relative to savings. In addition, FHHs in the North are less likely to scale back consumption relative to savings and MHHs in the Western region are less likely to increase labour supply relative to savings.[25] Furthermore, the odds of FHHs located in the Pastoral and Teso agro ecologies reducing consumption relative to savings are low. The same holds for MHHs in Montane and Pastoral systems in expanding labour supply relative to savings.

[24] Borrowing as an adaption option was automatically dropped from the estimation. Recall from the descriptive statistics, FHHs did not borrow when livestock epidemics occurred in both survey periods.
[25] The Western cattle corridor has the largest farms of beef cattle in Uganda followed by the East (MAAIF, 2009).

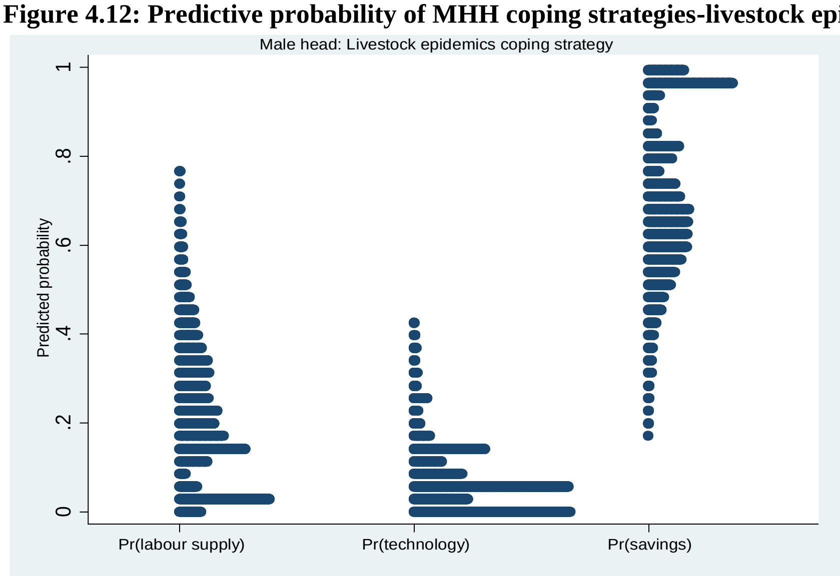
As shown in Figure 4.11, predictions for FHH coping strategies influenced by livestock epidemics indicate no discernible pattern in use of labour supply, savings and reducing consumption as shown by the descriptive statistics. Predictions confirm with descriptive analysis that MHHs resort to savings in the event that livestock epidemics occur (Figure 4.12).

Figure 4.11: Predictive probability for FHH coping strategies- livestock epidemics



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 4.12: Predictive probability of MHH coping strategies-livestock epidemics



Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table 4.9: Pooled MNL estimates by gender for factors determining coping strategies against livestock epidemics (RRRs)

	(1)		(2)	
	FHHs		MHHs	
Coping livestock epidemics	Labour supply	Reduce consumption	Labour supply	Technology
Age head	1.0501	1.1885*	0.999	0.9782
	(0.0499)	(0.1057)	(0.0239)	(0.0236)
Household size	0.7102**	0.7967	0.6712**	0.9221
	(0.1153)	(0.2796)	(0.1114)	(0.1765)
Urban	1.5469	106.8673	2.3456	0.3474
	(1.8813)	(295.0267)	(2.2547)	(0.7328)
Region				
East			0.8074	19.8796**
			(0.7943)	(28.801)
North	25.7093*	7.97e-08***	3.0718	8.7089
	(42.1985)	(1.89e-07)	(3.506)	(18.7451)
West			5.6681	3.05e-09***
			(10.9672)	(3.91e-09)
Land tenure system			0.2262*	0.0105**
			(0.2109)	(0.0213)
Distance to market			1.1511	1.1426
			(0.1278)	(0.1255)
Agro-ecologies				
Montane			0.0284	4.89e-09***
			(0.0732)	(6.74e-09)
Teso	8.9250	4.49e-10***	1.9052	4.7186
	(13.901)	(7.42e-10)	(2.2865)	(6.2372)
Pastoral	0.7511	2.71e-10***	0.0977**	1.37e-10***
	(1.0351)	(5.98e-10)	(0.1086)	(1.64e-10)
Diagnostics				
Un-weighted sample	29		83	
Weighted sample	25,936		89,438	
*Pseudo R*2	0.4729		0.1748	
Prob>chi	0.0000		0.0000	
Log likelihood	-13669.44		-65203.63	
Base outcome	Use savings		Use savings	

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

The diversity in livestock ownership in MHHs and FHHs are in tandem with the choices of adaptation strategies to livestock epidemics exacerbated by climate change. MHHs are more likely to own large livestock farms and FHHs have small-scale livestock rearing projects. Seo and Mendelsohn (2006) assert that small and large livestock farms respond to climates differently with large farms more responsive to climate shocks. The strategy to livestock epidemics is selling livestock, at low prices, increasing savings for MHHs. Asset ownership such as livestock and land in FHHs is limited (Agarwal, 1997; Deere and Doss, 2006; Ssewanyana and Kasirye, 2012) such that climate shocks drive them to expand labour and also sell their small assets such as jewellery. Simply put, households that are more diverse and have livestock (like MHHs in the Western region) appear to have a consistent income (savings) in times of epidemics, smoothening income from year to year.

4.6 Conclusion

In conclusion, this chapter discusses the different coping strategies employed in response to shocks from a gender perspective. Specifically, choices of adaptation strategies to covariate shocks disaggregated by the gender of household head are analysed. The findings show that choices of adaptation strategies to covariate shocks are similar in both female headed households (FHHs) and male headed households (MHHs) households but factors influencing the responses are not gender neutral. Coping strategies to covariate shocks reported by households are “last-resort” or “impromptu” responses, largely behavioural, hence informal in nature and ad-hoc. Specifically, survey findings show that FHHs reduce consumption through skipping number of meals eaten per day and scaling back food intake while MHHs utilise savings for example through selling of assets such as land, livestock, past savings, use of previous period ‘buffer stock’ and also reduce consumption during droughts.

Faced with livestock epidemics, MHHs use savings and FHHs provide more labour as coping strategies. Use of agricultural related technology and increased labour supply was higher during crop pests and disease outbreaks regardless of gender of the household head. Explanatory variables such, as age of the household head, distance to markets, land tenure system, area of residence, region, off-farm employment and agro ecological zones are key factors influencing choice of adaptation strategies for FHH and MHHs but direction of causality in some cases differs. The important role agro ecological zones play choices of adaptation strategies taken for FHHs and MHHs during covariate shocks is noted. The most observable gender differences in adaptation choices show up in the predictive probabilities figures. Such observable differences revealed in this chapter advocate for engendering the design and implementation processes of adaptation strategies in the advent of climate change disasters occurring by government and other stakeholders. Especially, enforcement of the land law to enable women feel secure (i.e. arable land ownership) as they are concerned with household food security and consumption, is crucial. More so, the possibility of allotting more rights to women in regard to arable land.

CHAPTER FIVE

ADAPTATION TO CLIMATE CHANGE IN UGANDA: A HOUSEHOLD WELFARE PERSPECTIVE

5.1 Introduction

This chapter aims at examining the combined impact of vectors of adaptation strategies taken to climate change induced shocks on household welfare.[26] As highlighted in the previous chapters, climate change induces disasters that trigger instant coping measures employed by households. Adaptation strategies taken as a result of the degree of impact and persistence of climate shocks occurring affect welfare. Heltberg and Lund (2009) and Okuyama (2009) write that a household naturally faces higher risks if it has to face multiple shocks as the impact gets carried over and makes coping difficult. The heterogeneity in adaptation interventions taken and their effectiveness in dealing with disasters matter. These have welfare implications.

As earlier argued in Chapter 1, few studies have quantified the impact of adaptation on food production (Di Falco et al., 2011) and none to my knowledge on welfare. Most research has concentrated on the impact of climate change on household welfare (Okuyama, 2009; Thomas et al., 2010; Skoufias et al., 2011). This study fills this gap and contributes to the literature on climate change, adaptation and well-being from a micro perspective. In particular for this chapter, we answer some salient questions in

[26]Welfare has largely been defined as a measurement of well-being of the people.

research: what are the most common adaptation strategies employed (for each covariate shock) by poor and non-poor households? To what extent are adaptation strategies employed by covariate shock effective on household well-being? That is, are the coping strategies resulting in “good” or “bad” outcomes. Put differently, analysing the impact of grouped choices of adaptation strategies to climate change induced shocks on household welfare is the crucial focus of this chapter using the Uganda National Panel Survey dataset of 2005/06 and 2009/10. Given the multidimensional nature of welfare and the various ways in which climate change and variability can impact on the different dimensions of household well-being, we limit our discussion to monetary measures (i.e. consumption expenditure per adult equivalent)[27] (Okwi et al, 2006).

The rest of the chapter is organised as follows. Section 5.2 reviews relevant literature relevant, Section 5.3 discusses the methodologies employed outlining the underlying reasons for model choices, and Section 5.4 describes the data and source. The main empirical results, analysis and discussions are presented in Section 5.5–first on descriptive statistics with regard to welfare indicators adaptation strategies and second on model estimates. Section 5.6 provides the conclusion of the chapter.

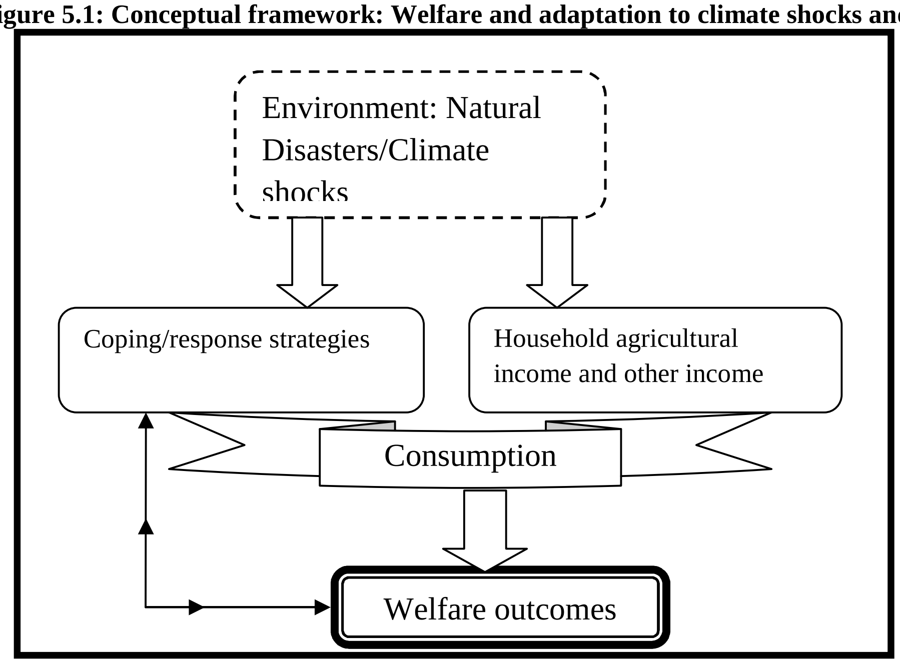
5.2 Literature review on welfare and adaptation to climate change

Substantial research on the impact of climate variability and change on household welfare and growth nexus exists (Eakin, 2000; Dercon, 2004; Matovu and Buyinza, 2010

[27]Our interest is not to pursue welfare estimation.

and Skoufias et al., 2011). For example, Skoufias et al. (2011) have shown the extent precipitation and temperatures impact on households' agricultural income and other income. In turn, they show the implications of this impact on consumption and health outcomes. Further shown is the direct link between coping response strategies and consumption patterns of households where such a combination of the causality consequently impacts on household welfare (Figure 5.1). In this case, Skoufias et al.(2011)argue that it is easier to think of these impacts in isolation of each other i.e. income and coping mechanisms on consumption and not vice versa.

Figure 5.1: Conceptual framework: Welfare and adaptation to climate shocks and change



Source: Author's own formulation based on Skoufias et al. (2011)

From Figure 5.1, climate shocks affect consumption mainly through their impact on current agricultural production or income. For example, because 80 percent of Uganda is rural and households depend largely on agriculture, any climate natural disaster impact on agricultural household’s income more. Nonetheless, shocks can also affect non-agricultural income for households involved in activities connected to weather such as provision of outdoor activities (Skoufias et al., 2011) or industries that depend on agricultural input. Depending on the household‘s ability to cope with income fluctuations, a negative income shock brought on by bad weather may translate into a reduction in consumption (e.g. Jacoby and Skoufias, 1998; Dercon and Krishnan, 2000) hence welfare loss. Implying that, adaptation mechanisms undertaken are welfare sensitive. Note the bi-directional arrows between coping strategies and welfare (Figure 5.1). Unlike Skoufias et al. (2011) where they assume exogeneity between consumption and adaptation to climate shocks, here the possibility endogeneity is assumed.

In a similar vein, Eakin (2000) and Skoufias et al. (2011) examine how smallholder farmers adapt to climatic risks in rural Mexico and Tlaxcala region of Mexico respectively. Both studies note that the current risk-coping mechanisms employed by rural Mexicans are not effective in protecting household welfare from erratic weather patterns. Furthermore, they assert that changes in climate indicator patterns associated with climate change are likely to reduce the effectiveness of the current coping mechanisms even more and further increase household vulnerability. Despite this grasp of what might happen, none of these earlier studies have directly estimated the degree of welfare loss or improvement as a result of responding to the covariate[28] climate shocks.

[28]Shocks that affect a large number of households in the same locality, such as weather related shocks.

On the other hand, Okwi et al. (2006) apply regressions analysis using a cross-section Uganda National Household Survey and strengthens their findings using spatially disaggregated poverty maps. They find that estimates of poverty measures improve when bio-physical information is included. The poverty estimates appear to be more robust, as the standard errors show a decline in some cases by up to 40 percent. Nonetheless, the paper does not explore further welfare linkages between climate change adaptations to climate shocks.

As in Okwi et al. (2006), Thomas et al. (2010) analyse the impact of natural disasters on human welfare in Vietnam. Other than providing spatially disaggregated disaster maps, the effects of natural disasters and other shocks on household welfare are assessed by augmenting a standard reduced form consumption model with explicit measures of the disasters included. Their econometric results suggest that households in Vietnam manage to cope with immediate effects of drought events mainly through irrigation. They also write that the increased frequency of droughts has eroded households' capacity to cope effectively, especially those located in drought prone areas closer to urban centres. They conclude that disasters result into substantial welfare losses as relief is less pronounced. They further note that the long run effects on welfare damages from frequent exposure to localised floods are substantially less than those from frequent exposure to droughts. Reason being that the responsive relief system is more pronounced during floods in affected areas than during droughts. The largest damage on welfare was as a result of hurricane winds on households in regular exposure and proximity to urban areas.

Findings in this study are useful in providing a bench mark for this study on impact of adaptation to large frequent natural disasters on welfare.

Mansur et al. (2007) applies the Dubin and McFadden model on cross-sectional data and estimates a national energy model of fuel choice for households and firms across the United States. Their regression results suggest that fuel choice component is an important aspect of adjustment to climate change. In warmer climates, both firms and households tend to choose electricity for heating and cooling. Furthermore, consumers in warmer locations rely relatively more heavily on electricity rather than natural gas, oil, and other fuels. They conclude that climate change will increase electricity consumption on cooling and reduce the use of other fuels for heating. As a result, on average, energy expenditure in America is likely to increase as household adapt to climate extremes, resulting in welfare damages as temperatures rise.

Matovu and Buyinza (2010) combine household survey data, the Social Accounting Matrix (SAM) and data from the Uganda Department of Meteorology to analyse growth and household welfare effects of climate change in Uganda. Empirical estimates using the Cobb-Douglas production function and the Computable General Equilibrium (CGE) framework reveal interesting results. Regression results indicate that both erratic rainfall and changing temperatures had a negative impact on crop production but this varied by crop. CGE estimates indicated that growth in the agricultural sector would decline by 0.7-0.9 percent. On the macroeconomic front, individual impacts of a permanent increase in temperature and rainfall changes on overall GDP are found to be minor but the combined effects on productivity and welfare for the projection period 2008-2015 are high. More succinctly, in season 1 alone, the proportion of people who fall below the poverty line is 0.5 percent due to climate change. It is projected that poverty in rural households engaged in farming activities will increase by 0.6 percent if climate conditions persist as exhibited in the past. The limitation of this paper is that the methodology is mainly applied for impact analysis and not adaptation to climate change. Generally, the CGE framework is narrow in analysing welfare as it uses poverty as a measure of welfare. This study uses household consumption expenditure per adult equivalent as a proxy for welfare. This form of measurement is widely recommended in academic literature.

A study by Di Falco et al. (2011) uses cross-sectional data from 1000 households from the Nile Basin of Ethiopia to examine the effects of adaptation to climate change on food security. They generate household specific rainfall and temperature data using the *Thin plate spline method* and account for possible endogeneity in decisions to adapt by estimating a simultaneous equations model with endogenous switching using Full Information Maximum Likelihood estimator. Remarkably, they find a significant and non-negligible difference in food productivity between the farm households that adapted and those that did not adapt to climate change. Nonetheless, adaptation to climate change increased food productivity. They further analyse the drivers behind adaptation by controlling for households that adapted and those that did not. Finding also reveal that information on both farming practices (irrespective of its source) and climate change was crucial in affecting the probability of adaptation. Farm households with access to credit are more likely to undertake strategies to tackle climate change. However, they make no attempt to disentangle adaptation to understand which adaptation measures by climate disaster actually affect food security more nor do they estimate adaption to climate change effects on welfare in general.

In conclusion, the literature reviewed in this subsection is biased towards climate change impact-welfare analysis. The authors do not attempt to estimate adaptation to climate change-welfare relationship. The authors who attempt this have captured adaptation in a crude way (that is either you adapted or you did not), however, the choices of adaptation strategies actually employed matter, though not examined. Despite these short comings, insights from these specific studies are crucial in appreciating the extent of the problem in regard to the gap in literature this study fills in examining the impact of choice of adaptation strategies to climate change induced shocks on welfare.

5.3 Methodology

5.3.1 Conceptual framework

The theoretical basis for the consumption based measure of welfare is well detailed in Deaton and Zaidi (1999). In this study, our welfare measure does not consider other important welfare, such as freedom, health status, life-expectancy, or levels of education, all of which are related to income and consumption, but which cannot be adequately captured by any simple monetary measure. Consumption is a theoretically more satisfactory measure of well-being as it is less variable over the period of a year, much more stable than income in agricultural economies and which makes it more reasonable to extrapolate from two weeks to a year for a survey household (Deaton and Zaidi, 1999). In most developing countries where Living Standard Measurement Surveys (LSMS) and /or household budget surveys are available such as in Uganda, consumption expenditure per adult equivalent is the appropriate measure to proxy for welfare.

In most cases, the social welfare function we use is defined as a function of the utility levels of individuals. That is, the utility function for individual i is of the form $u(q_i, x_i)$, where q_i is a vector of commodities consumed, and x_i is a vector of welfare-relevant "non-income" characteristics, including demographic characteristics of the household. The utility maximising consumption vector is denoted $q(p_i, y_i, x_i)$ at price vector p_i and total expenditure on consumption y_i. The implied indirect utility function is $v(p_i, y_i, x_i)$, giving the maximum attainable welfare at prevailing prices and characteristics. On inverting, we obtain the expenditure function $e(p_i, x_i, u)$ giving the minimum cost of utility u for person i when facing prices p_i.

From the foregoing, it is assumed that households have the same utility function, which is determined by the household characteristics such as sex, age and household size. In this study like in Okwi (1998), the 'money metric is used to label the indifference curve which possesses two main features namely; (1) allowance for the distribution between individuals at different levels of utility given observable data, and (2) does not imply any cardinalisation of the common individual utility function. The money metric utility[29] is used to compare the different households' utility curves. This is based on the premise that total consumption as opposed to total income, represents the welfare levels of individuals.

Another aspect that we consider is the effect of additional household members "especially the children" on household expenditure. Additional members increase the costs of households but children do not increase these costs by as a much as adults. Therefore, children are believed to take a small proportion or consume less of the total expenditures and they are considered as fractions of adults. The concept is derived from Deaton and Muellbauer (1980) and Appleton (2001). The adult equivalent scale system allocates weights to different members of the household by age and the scale ranges from zero to one (i.e. one can assume a weight between zero and one). Under this system, children will be given smaller weights than adults. The equivalent scales used in this study are adopted from Appleton (2001). The sum of weights for each household is used to divide household consumption expenditures to arrive at a measure of welfare.[30]

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[29]Money metric utility is the amount required to sustain a level of living and requires that consumption be adjusted by a Paasche Price Index (PPI) that reflects the prices the household faces and whose weights are different for each household.

[30] There is contention in policy and literature debates on the use of only one measure of welfare. Here, briefly explored are other three measures. These are: (1) welfare calculated at low per adult caloric requirement (*welfare_l*), (2) welfare calculated at medium per adult caloric requirement (*welfare_m*) and (3) welfare calculated at high per adult caloric requirement (*welfare_h*). Results presented and discussed in

Recall earlier on in our literature review, we conceptualise that choice of adaptation strategies employed when climate change induced disasters occur affect welfare. In turn the level of welfare has a possibility in influencing the decisions a household takes in choosing a certain adaptation strategy over another in response to climate shocks. Hence, endogeneity can arise in our model formulation. This is further explored in this section.

5.3.2 The Model

Following Skoufias et al. (2011), we apply OLS on pooled data[31] and estimate the aggregated impact of adaptation strategies for each covariate shock on welfare. Our general model specification is:

$$\ln C_{h,l,t} = \sim + \quad AS_{h,l,t} + \pounds_{h,l,t} \qquad (5.1)$$

Where, $\ln C_{h,l,t}$ is natural logarithm of household welfare measured as consumption expenditure per adult equivalent of household, h, located in locality l, in year t. $AS_{h,l,t}$ is a vector describing choice of adaptation/coping strategies by household, h, in locality l, at time t and $\pounds_{h,l,t}$ is the error term. Inclusion of controls in Equation 5.1 leads to its re-specification, that is:

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this study are for the general welfare measure and results for other measures for comparability are available upon request.

[31]The underlying reasons for pooling panel data and model choice rather than use the conventional panel data methods is: (1) our climate indicators –agro-ecological climate zones are fixed effects variables thus use of the panel Fixed Effects (FE) estimator renders all binary fixed variables, which are central in our analysis, to be dropped. (2) In STATA 12.0, Panel Random Effects (RE) estimator does not accommodate use of "panel weights" in estimations and our analysis is at country level not at sample level.

$$\ln C_{h,l,t} = \text{~} + \quad AS_{h,l,t} + \text{¥}X_{h,l,t} + \text{«}_{l} + \text{°}_{t} + \text{³}_{h,l,t} \qquad (5.2)$$

Where now $\ln C_{h,l,t}$ and $AS_{h,l,t}$ are defined as before. $X_{h,l,t}$ is a vector of other factors explaining consumption levels, such as assets ownership and household characteristics. «_{l} are locality fixed effects which control for local, time invariant characteristics such as the agro-ecological climatic zone characteristics of each locality, °_{t} controls for the survey year differences, and $\text{³}_{h,l,t}$ is the random error term with measuring the impact of choice of coping strategies by shock on welfare.

To address heterogeneity and endogeneity, we assume that choice of adaptation strategies (AS) is endogenous in equations (5.1) and (5.2) hence application of OLS produces biased and inconsistent estimates (Cameron and Trivedi, 2010; Greene, 2012; and Wooldridge, 2012). Thus, we employ the Instrumental Variable (IV) technique and test for endogeneity in estimates (Wooldridge, 2012; Greene, 2012; Cameron and Trivedi, 2010). The IV estimation is made possible by using a variable $Z_{h,l,t}$ that is (1) uncorrelated with the error terms $\text{£}_{h,l,t}$ and $\text{³}_{h,l,t}$, (2) correlated with our troublesome explanatory, $AS_{h,l,t}$, and (3) not an explanatory variable in the original equation. Thus, $Z_{h,l,t}$ is referred to as the Instrumental Variable. Use of $Z_{h,l,t}$ in our estimations leads to estimating coefficients of equation (5.1) and (5.2) consistently by using the two-stage least squares (2SLS) instrumental variable estimator. The first stage (often called a "reduced-form equation") regresses $AS_{h,l,t}$ on both the IV and other exogenous explanatory variables $X_{h,l,t}$ using OLS is:

$$AS_{h,l,t} = \sim_0 + Z_{h,l,t}\sim_1 + X_{h,l,t}\sim_2 + \text{g}_{h,l,t} \quad (5.3)$$

Where $\text{g}_{h,l,t}$ is the error term. We then use the OLS coefficient estimates from the first-stage regression to form fitted values of $\hat{A}S_{h,l,t}$. In the second stage of the 2SLS, these fitted values, $\hat{A}S_{h,l,t}$, are substituted for actual values, $AS_{h,l,t}$, in an OLS regression of $\ln C_{h,l,t}$ on $X_{h,l,t}$ and $\hat{A}S_{h,l,t}$. Thus, the second-stage coefficient estimates are the 2SLS estimates. As Greene (2012) points out, the 2SLS estimator has larger standard errors compared to OLS's.

Specifically, in controlling for potential endogeneity of the unordered variable choice of coping strategies adopted, using IV 2SLS method on welfare-a continuous variable, Angrist (2001) and Angrist and Krueger (2001) argue that even in the case of a discrete variable in the first of the two equations, 2SLS produces consistent estimators that are less sensitive to assumptions on the functional form.

Finally, in equation 5.2 we introduce interaction terms, that is becomes:

$$\ln C_{h,l,t} = \sim + {}_0 AS_{h,l,t} + {}_1(AS_{h,l,t} * W_{h,l,t}) + \yen_1 W_{h,l,t} + \yen_2 X_{h,l,t} + «_l + °_t + {}^3{}_{h,l,t} \quad (5.4)$$

Here, $W_{h,l,t}$ identifies the household characteristics such as headship, education and age. In this case $_0$ measures the impact of the coping strategies on households without that particular characteristic and $(_0 + _1)$ measures the impact of coping strategies on households with that particular characteristic, with $_1$ denoting the difference in the impact between the two groups.

Throughout our analysis, we use natural logarithms of our dependent variable, welfare in model estimations.[32]

Robustness checks

We test for weak identification, validity and exogeneity of the instrumental variable using the Hansen's J test (Davidson and Mackinnon, 2004). In all cases, this test fails to reject the null hypothesis that the instrument (region) is valid and exogenous (results not shown). Specifically, the individual validity test of the IV strength is done by estimating reduced form equations with IV (region) as the explanatory variable and $AS_{h,l,t}$ as the dependent variable (Murray, 2006). In all specifications, the IV coefficient is statistically significant from zero with an overall model fit at 1 percent level of significance, implying region is a strong IV for $AS_{h,l,t}$. In addition, to test whether the endogenous regressor $AS_{h,l,t}$ in the model is exogenous, after estimating IV 2SLS with cluster robust

[32]For comparison, equations (5.1), (5.2) and (5.4) are estimated using both OLS and IV 2SLS estimators on pooled data.

option estimations, we use Wooldridge's (1995) robust score test and a robust regression-based test. In all cases, if the test statistic is significant, then $AS_{h,l,t}$ must be treated as endogenous otherwise it's exogenous. Implying that, OLS estimates are better than 2SLS results. Throughout, we use the Huber-white standard errors clustered at the household level to control for heteroskedasticity in estimates and we control for strata specific fixed effects.

5.3.3 Hypotheses tested

The following hypotheses are tested:

i. We hypothesise that in the absence of insurance against income shocks any response strategy for any climate shock that reduces income should also reduce consumption and vice versa.

ii. Gender of household head: Female headed households are likely to experience higher welfare losses or gains than male headed households if they take measures against climate distresses.

iii. Age of the household head and level of education: it is hypothesized that households with older heads and low level of education will have higher welfare losses.

iv. Community indicators such as farm size and tenure system can have either a positive or negative impact on welfare.

v. Area of residence, agro-ecological climate zone and household size are hypothesized to have either a positive or negative correlation with welfare depending on type of shock households are adapting to.

5.4 Data sources and data transformation

Data utilised in this chapter is identical to that described in chapter four, a balanced panel of 2,566 original households. However, this chapter takes a step further by including the welfare level of the household. In the panel survey social economic modules, they record consumption expenditure in which different recall periods are used to capture information on the different sub-components of household expenditures (UNHS III, 2005/06; UNPS, 2009/10). That is, a 7-day recall period is used for expenditure on food, beverages and tobacco, a 30-day recall period is used in the case of household consumption expenditure on non-durable goods and frequently purchased services; while a 365-day recall period is used for semi-durable and durable goods and services; and non-consumption expenditures (UBoS, 2006; 2010). In both surveys, all purchases by household members and items received as free gifts are valued and recorded using the current prices. The items consumed out of home produce are valued at the current farm-gate/ producer prices while rent for owner-occupied houses is imputed at current market prices. Food consumption includes food consumed from own-production, purchases and free collection/gifts.

Expenditure data was collected on an item-by-item basis. The expenditures are then aggregated according to the recall period used and by broader sub-components of expenditures to the household level. Given the different recall periods that are used during the collection of data on household expenditures, some conversion factors are applied to change the data to a 30-day (monthly) basis. After which, all the different sub-components of the expenditures are aggregated to derive the total consumption expenditures at household level. Throughout the analysis, non-consumption expenditures are excluded in the construction of the consumption expenditure aggregate (Ssewanyana and Kasirye, 2012). Further adjustments are made in the construction of consumption expenditure that is used to proxy for welfare. These adjustments include accounting for inter-temporal and spatial price variations, revaluation of foods derived from own-consumption into market prices and finally accounting for household composition in terms of sex and age (for further details see Appleton, 2001; Ssewanyana and Kasirye, 2012, for the construction of the consumption expenditure per adult equivalent variable that is used to proxy for household welfare in this paper).

Sampling weights are used throughout the analysis to account for under and over sampling in EAs, making the survey data nationally representative. In addition, as in Chapter Four, analysis is at household level unless otherwise stated.

5.5 Results and discussion

5.5.1 Descriptive analysis

In addition to the variables description in chapter four, Table 5.1 presents summary statistics of welfare (continuous variable) and poverty status of households. About 24.7 percent of the households in the panel are poor. Differences in welfare averages are noted at various measures.

Table 5.1: Added summary statistics

Variable name	Variable label	Obs	Mean	Std. Dev.	Min	Max
Welfare	Consumption expenditure per adult equivalent (shillings)	5170	68116.37	79147.42	3525.114	1785754
welfare_l	Consumption expenditure per low adult caloric equivalent (shillings)	5170	73032.26	85340.58	3780.24	1944781
welfare_m	Consumption expenditure per medium adult caloric equivalent (shillings)	5170	70619.3	81136.99	3706.823	1794385
welfare_h	Consumption expenditure per high adult caloric equivalent (shillings)	5170	67269.87	75721.58	3601.892	1621920
Poor	Poverty status dummy variable; 1 if poor	5170	0.2470019	0.4313096	0	1

Note: Poor households are those with consumption below the poverty lines and non-poor households are those households whose consumption is above the poverty line.
Source: Author's calculations based on the 2005/06 and 2009/10 panel

5.5.1.1 Heterogeneity in welfare distribution

At the national level, the mean of this welfare measure increases from Ushs.66,821 per month per adult equivalent in 2005/06 survey to Ushs.76,067 per month per adult equivalent in the 2009/10 panel survey; equivalent to an increase of about 14 percent (UBoS Panel Dataset, 2012).

Table 5.2, provides insights into the distribution of income between the survey periods. In Table 5.2 and Appendix C: Table C.1, presented is a welfare level for real consumption per adult equivalent at the median and other deciles. At the median (decile 5), our welfare measure increases from Ushs.48,429 to Ushs.50,682 corresponding to an increase of about 4.7 percent between the survey periods. Simply put welfare increases both at the mean and at the median but much stronger at the mean than at the median. We note the negative percentage change in welfare at the national level at the 8^{th} and 9^{th} deciles (the lower bounds of the 20 percent relatively rich Ugandans) of about 0.7 percent and 1.6 percent respectively. Nonetheless, Table 5.2 also indicates an exceptional increase in welfare in 2009/10 from 2005/06 by area of residence with strong increase in the urban households at the 7^{th} and 8^{th} deciles of about 18.6 and 15.7 percent respectively. Generally, the pattern in rural areas is close to that of the country as whole than that for urban areas where the picture is different (findings are in line with socio-economic 2005/06 and 2009/10 reports).

Table 5.2: Consumption expenditure per adult equivalent at each decile (UShs.)

	2005/06	2009/10	2005-2010 (%_change)
National			
Decile 1	20,966	21,293	1.6
Decile 2	27,184	28,586	5.2
Decile 3	34,016	35,256	3.6
Decile 4	40,716	42,643	4.7
Decile 5	48,429	50,682	4.7
Decile 6	59,544	60,386	1.4
Decile 7	74,327	75,011	0.9
Decile 8	97,433	96,785	-0.7
Decile 9	142,822	140,590	-1.6
Rural			
Decile 1	18,758	19,972	6.5
Decile 2	23,998	26,603	10.9
Decile 3	28,898	32,549	12.6
Decile 4	34,196	38,767	13.4
Decile 5	39,703	45,248	14.0
Decile 6	46,637	52,643	12.9
Decile 7	55,002	62,490	13.6
Decile 8	70,618	77,978	10.4
Decile 9	96,024	106,333	10.7
Urban			
Decile 1	37,859	38,391	1.4
Decile 2	53,080	56,248	6.0
Decile 3	65,927	72,201	9.5
Decile 4	78,740	87,621	11.3
Decile 5	92,441	101,872	10.2
Decile 6	110,639	119,474	8.0
Decile 7	132,839	157,609	18.6
Decile 8	176,526	204,217	15.7
Decile 9	247,819	277,211	11.9

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Comparative statistics of poverty status by gender of the household head and area of residence are presented in Table 5.3. The proportion of poor households reduced from 24.6 percent in 2005/06 to 20.5 percent in 2009/10. Other differences in poverty status by gender and residence can be observed in Table.5.3. This supports evidence that overall headcount poverty had declined from 31.1 in 2005/06 to 24.5 percent in 2009/10 (UBoS, 2010).

Table 5.3: Poverty status by gender of household head and residence (% of total)

	2005/06			2009/10		
	Poor	Non-poor	*All*	Poor	Non-poor	*All*
Gender of Household head						
Female	7.3	20.0	*27.3*	6.3	22.2	*28.5*
Male	17.3	55.4	*72.7*	14.2	57.4	*71.5*
Area of residence						
Rural	23.35	54.66	*78.01*	19.22	62.54	*81.77*
Urban	1.24	20.75	*21.99*	1.23	17.01	*18.23*
All	*24.59*	*75.41*	*100*	*20.45*	*79.55*	*100*

Note: Analysis based on 2,566 households covered on both surveys
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Figure 5.2, shows the distribution of income (consumption expenditure is used to proxy for permanent income) by household size and year of survey, gender of household head and poverty status. In particular, Figure 5.2a illustrates the distribution of income by household size for 2005/06 and 2009/10. The distribution indicates an increase in household income between the survey periods. Households with larger numbers of people have low income. The findings support the welfare results in Table 5.1. With regard to income distribution by gender of household head, Figure 5.2b indicates that households that were female headed had relatively low income (many with less than Ushs.500,000 per month) compared to male headed households. This emphasises the relative vulnerability of FHHs.

Figure 5.2: Distribution of income (Ushs) by household size, gender and poverty status

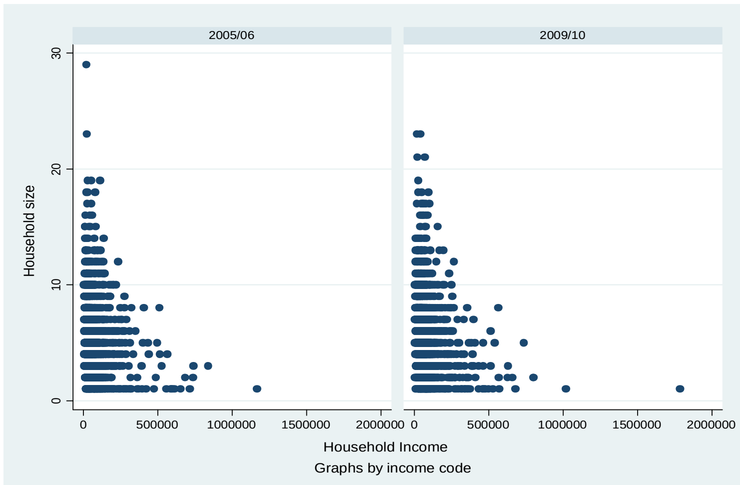

Figure 5.2a

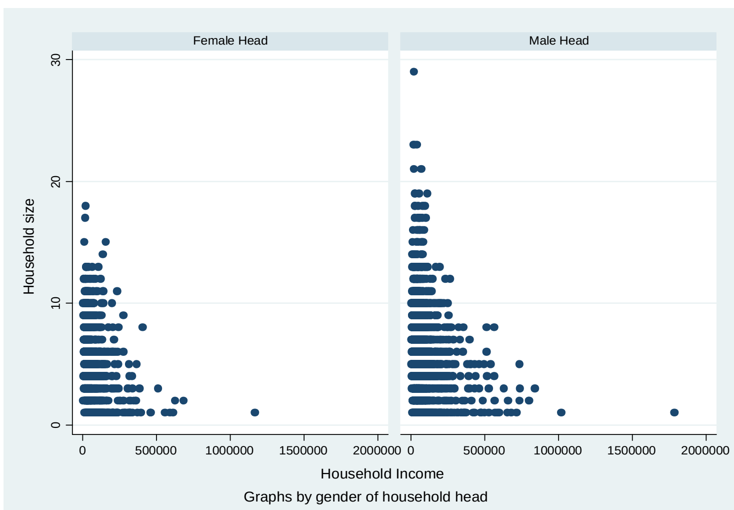

Figure 5.2b

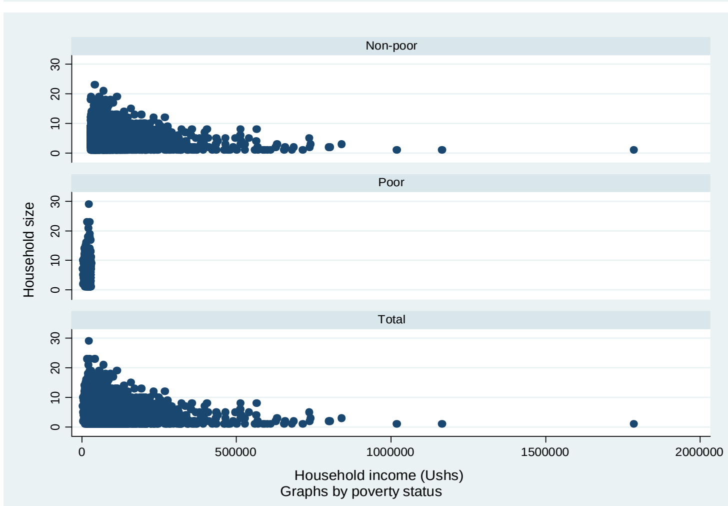

Figure 5.2c

Source: Author's calculations based on the 2005/06 and 2009/10 panel

And lastly, Figure 5.2c provides insights into the distribution of income by poverty status and household size. The poor have annual income below Ushs.100,000 and with a relatively high number of household size compared to the non-poor households.

5.5.1.2 Heterogeneity in adaptation strategies by covariate shock

(i) Choice of adaptation strategies to shocks and area of residence

Table 5.4 shows that rural households are the most affected by climate shocks and coping strategies are largely driven by the rural household composition in our survey data. Choice of adaptation to a shock is not uniform between the survey periods. That is for households located in rural areas; use of savings was the most commonly cited choice of adaptation during droughts in 2005/06, however, in 2009/10 household mainly reduced consumption through scaling back meals and skipping meals. Urban households adapted during drought by increasing labour supply, use of savings and reducing consumption. During floods and livestock epidemics, households in rural and urban areas did not access any informal or formal credit institutions but again urban households did not increase labour supply, use technology and in some incidences even use savings during shocks. Many of the shocks affect agricultural activities, which depend on nature and a source of livelihood for many rural households.

In Heltberg and Lund (2009); Di Falco et al. (2011) and Heltberg (2012) studies they assert that poor households in developing countries often suffer a multitude of risks affecting their livelihood and these are located more in rural areas. For households with agriculture as their main source of income, risk is a pervasive factor, and ecological risks such as drought, crop pests, or livestock diseases can reduce income sharply. Similarly, price fluctuations in input and output markets affect households and how they cope with shocks.

Table 5.4: Coping strategies by covariate shock and area of residence (% of total)

Coping Strategy	Drought			Floods			Pests			Livestock Epidemics		
2005/06												
	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All
Borrowing	3.7	0.1	3.8	5.6	0.4	6.0	1.1	0.0	1.1	2.2	0.0	2.2
Labour supply	23.7	1.0	24.7	22.6	0.9	23.5	18.6	0.8	19.4	33.5	2.1	35.6
Technology	4.3	0.1	4.4	7.9	0.6	8.4	39.3	1.0	40.3	10.4	0.8	11.2
Savings	35.5	3.1	38.6	36.0	2.5	38.5	16.5	4.5	21.0	45.1	2.7	47.8
Reduce consumption	26.2	2.3	28.5	22.7	0.8	23.5	16.9	1.4	18.2	3.1	0.0	3.1
2009/10												
	Drought			Floods			Pests			Livestock Epidemics		
	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All	Rural	Urban	All
Borrowing	1.7	0.1	1.8	0.0	0.0	0.0	1.8	2.7	4.5	0.0	0.0	0.0
Labour supply	18.1	2.0	20.0	25.4	0.0	25.4	7.9	1.9	9.8	9.9	0.0	9.9
Technology	4.9	0.3	5.2	5.4	0.0	5.4	20.4	0.8	21.2	6.7	0.0	6.7
Savings	23.4	2.0	25.4	18.0	0.0	18.0	22.7	4.2	26.9	67.8	6.3	74.1
Reduce consumption	45.5	2.0	47.5	44.8	6.3	51.1	30.7	6.8	37.6	4.4	5.0	9.4

Source: Author's calculations based on the 2005/06 and 2009/10 panel

(ii) Chi square test between adaptation strategies by shock and poverty status

A chi square independence test is performed to test if poverty status is statistically significantly correlated with coping strategies employed for each climate shocks/natural disasters. The null hypothesis: choices of coping strategies employed by shock employed are independent of the poverty status of the household. Results of the chi-square test for independence are presented below.

Coping during drought:	Pearson chi2(4) = 8.7e+04	Pr = 0.000
Coping during floods:	Pearson chi2(4) = 4.0e+03	Pr = 0.000
Coping during pests:	Pearson chi2(4) = 7.6e+03	Pr = 0.000
Coping during livestock epidemics:	Pearson chi2(4) = 4.5e+03	Pr = 0.000

Test results reveal that we reject all the null hypotheses of independence for all vectors of coping strategies to climate shocks at 1 percent level of significance.

(iii) Choice of adaptation strategies to shocks and poverty status

Table 5.5 presents a multivariate analysis between adaptation to shocks and poverty status of households. Findings reveal that, in coping with drought, poor households consistently reduce consumption/reduce food intake while the non-poor increase use of their savings and reduce food intake across the survey periods. Whereas the next best response for non-poor households during risks is revert to use of savings, the poor households reduce food intakes and also increase labour supply (Heltberg and Lund, 2009; Heltberg et al., 2012). A large covariate climate induced shock, apart from its instantaneous impact, continues to influence and shape households behavioural responses in an extended time horizon which ultimately impact on welfare in both the short and long rum (Heltberg and Lund, 2009).

Table 5.5: Coping strategies by covariate shock and poverty status (% of total)

	2005/06											
	Drought			Floods			Pests			Livestock Epidemics		
Coping strategy	Non-poor	Poor	All	Non-poor	Poor	All	Non-poor	Poor	All	Non-poor	Poor	All
Borrowing	2.7	1.1	3.8	3.8	2.3	6.0	0.6	0.5	1.1	2.2	0.0	2.2
Labour supply	13.3	11.5	24.7	16.1	7.4	23.5	13.9	5.4	19.4	26.7	8.9	35.6
Technology	2.6	1.8	4.4	4.9	3.5	8.4	32.9	7.4	40.3	9.8	1.4	11.2
Savings	30.1	8.4	38.6	31.0	7.5	38.5	17.2	3.8	21.0	37.0	10.8	47.8
Reduce consumption	18.2	10.3	28.5	17.7	5.8	23.5	12.2	6.1	18.2	1.0	2.1	3.1
	2009/10											
	Drought			Floods			Pests			Livestock Epidemics		
	Non-poor	Poor	All	Non-poor	Poor	All	Non-poor	Poor	All	Non-poor	Poor	All
Borrowing	1.5	0.3	1.8	0.0	0.0	0.0	2.7	1.8	4.5	0.0	0.0	0.0
Labour supply	14.1	5.9	20.0	17.6	7.8	25.4	7.0	2.8	9.8	6.8	3.0	9.9
Technology	4.4	0.8	5.2	5.4	0.0	5.4	18.0	3.3	21.2	6.7	0.0	6.7
Savings	22.7	2.7	25.4	9.6	8.5	18.0	25.2	1.7	26.9	69.9	4.2	74.1
Reduce consumption	33.6	13.9	47.5	40.7	10.4	51.1	32.5	5.0	37.6	9.4	0.0	9.4

Source: Author's calculations based on the 2005/06 and 2009/10 panel

5.5.2 Empirical results, analysis and discussion

Presented in Table 5.6 is the Pair-wise correlation matrix between the dependent variable ($\ln welfare$) and the regressors. Results show that the vectors for choices of coping strategies due to drought, pests and livestock epidemics are negatively correlated with welfare, only the coping strategies undertaken in the event that floods occur are positively correlated with welfare. Area of residence (urban; 1 if urban) has a positive correlation with welfare. Gender of household head (1 if male head) and farm size are positively correlated with welfare. Age of household head, household size, land tenure system (1 if formal) and agro-ecological climate zones are all negatively correlated with welfare. Finally, education is positively correlated with welfare. Most of the signs of the explanatory variables concur with economic theory as they can go either way (positive or negative) depending on the capacity in which the coping strategies are used to further improve household well-being (see Skoufias et at., 2011 for similar findings).

Table 5.6: Pair wise correlation matrix of explanatory variables and log welfare

	*ln*Welfare	Cop drought	Cop floods	Cop pests	Cop lepidemic	Urban	Gender head	Age head	HH size	Farm size	Tenure	Educ father	Agro-ecology
*ln*Welfare	1												
Cop drought	-0.021	1											
Cop floods	0.103	0.547	1										
Cop pests	-0.010	0.432	0.404	1									
Cop lepidemic	-0.015	0.404	0.437	0.320	1								
Urban	0.400	-0.008	-0.010	0.065	-0.049	1							
Gender head	0.014	-0.031	0.076	-0.051	0.041	-0.040	1						
Age head	-0.063	0.066	-0.044	0.211	-0.031	-0.077	-0.155	1					
HH size	-0.235	0.024	-0.027	-0.018	0.170	-0.083	0.166	0.113	1				
Farm size	0.026	0.016	-0.069	-0.049	0.041	-0.054	0.052	0.051	0.048	1			
Tenure	-0.227	-0.175	-0.156	-0.199	-0.042	-0.089	0.004	-0.070	-0.069	0.014	1		
Educ father	0.303	0.039	-0.075	-0.024	-0.056	0.260	-0.103	0.000	0.082	0.003	-0.095	1	
Agro-ecology	-0.321	-0.133	-0.140	-0.142	-0.158	-0.176	-0.022	0.026	0.013	0.056	0.437	-0.146	1

Source: Author's calculations based on the 2005/06 and 2009/10 panel

5.5.2.1 Aggregated impact of adaptation strategies by shock on welfare

Table5.7 presents results of the pooled OLS model applied on equations (5.1) for the aggregated impact of adaptation strategies by covariate shock (i.e. drought, floods, crop pest attacks, and livestock epidemics on household welfare (lnwelfare). Estimates of equation (5.2) are also presented. Further controlled for is the poverty status of households in both specifications.

A couple of points are worth highlighting. First, column (1) estimates indicate that at the national level coping measures employed during droughts and floods (mainly scaling back food intakes and selling of assets mainly land) reduce welfare by 31.3 percent and 15.9 percent while coping strategies employed during livestock epidemics (which involve mainly use of savings through sell of livestock mostly below market prices) (see various FEWSNET reports and Humanitarian Profile reports 2011; 2012). Second, controlling for poverty status of the households (2 and 3),shows that during droughts, both poor and non-poor households adaptation strategies lead to welfare losses while adaptation strategies during floods lead to 14.5 percent losses in non-poor households.

Issuing of safety nets and emergence aid is faster during floods short term and region specific than during droughts (more long term and affect all regions). The coping strategies during livestock epidemics had a much higher and statistically significant impact on the welfare for poor households. Heltberg and Lund, (2009) and Heltberg et al. (2012) report that while spending precautionary savings or borrowing from friends and relatives may be relatively harmless, selling or mortgaging of land, house and productive assets can seriously jeopardize households' livelihoods.

Third, inclusion of further robustness checks in columns (4), (5) and (6) reveal that only coping strategies employed during livestock epidemics still significantly impact on welfare at the national level (19.4 percent) and particularly for poor households (13.7 percent) (Table 5.7). Other factors that significantly and positively impact on welfare are being a male headed households (Denton, 2002), education of the household head (Skoufias et al., 2011), age of household head[33], area of residence and being located in the Banana/coffee, Banana/millet/cotton, Montane and Teso agro-ecologies (Deressa et al., 2008 and Below et al., 2010) both at the national level and non-poor households (see Table 5.6). However, household size at the national level and for both poor and non-poor households and being located in the Pastoral agro-ecology for poor households negatively impacts on welfare. As Skoufias et al. (2011) argue, the quality of household members matter such that expanding labour supply of adults could be quite acceptable (depending on hours worked already and the type of employment) while sending children to work can erode their human capital which impact negatively on welfare. In addition, heterogeneity in agro ecological findings, in particular, where for non-poor households located in the Pastoral agro-ecology realise a positive impact on welfare and the converse holds for poor households. This suggests that some households are either able to protect themselves after the shock by adapting ex-post mechanisms such as

[33]We included age square in our estimates to account for life cycle hypothesis, but coefficients were not significant throughout, thus we dropped the variable.

changing their agricultural practices specific to their agro ecological climate zone in response to the climate distress event. Or, in the case of reduced revenue from agriculture, households are able ex-ante to the shock keep welfare from declining. But in some households, coping measures employed by households deepen poverty especially among the already poor (Dercon, 2002; Heltberg and Lund, 2009).

In conclusion, the approach taken here, assumes that choices of adaptation strategies to climate change induced shocks are exogenous. Results presented in the next subsection address heterogeneity in adaptation strategies impacts for each shock on welfare and possible endogeneity that may arises in single troublesome regressor model specifications.

Table 5.7: Pooled OLS estimates for impact of adaptation strategies by shock on household welfare

	(1)	(2)	(3)	(4)	(5)	(6)
Log of welfare	All	Non-poor	Poor	All	Non-poor	Poor
Cope drought	-0.313***	-0.270***	-0.0604**	-0.0404	-0.0370	-0.0351
	(0.0373)	(0.0338)	(0.0282)	(0.0360)	(0.0321)	(0.0267)
Cope floods	-0.159**	-0.145***	0.0120	-0.0293	-0.0508	0.0168
	(0.0577)	(0.0375)	(0.0414)	(0.0505)	(0.0441)	(0.0372)
Cope pests	0.0489	-0.0125	0.0657	0.00769	0.00142	0.0281
	(0.0611)	(0.0579)	(0.0491)	(0.0719)	(0.0716)	(0.0435)
Cope livestock epidemic	0.154**	0.0404	0.175***	0.194**	0.0863	0.137**
	(0.0611)	(0.0608)	(0.0460)	(0.0625)	(0.0654)	(0.0427)
HH size				-0.0460***	-0.0357***	-0.00970*
				(0.00470)	(0.00484)	(0.00376)
Age head				0.00216**	0.00223**	-0.00144
				(0.00107)	(0.000870)	(0.000800)
Gender head				0.153***	0.0964**	0.0361
				(0.0348)	(0.0304)	(0.0242)
Male head's education						
Secondary				0.220***	0.160***	0.0220
				(0.0380)	(0.0348)	(0.0288)
Tertiary				0.560***	0.485***	0.203***
				(0.0767)	(0.0756)	(0.0612)
Female head's education						

Secondary				0.237***	0.184***	0.0265
				(0.0545)	(0.0446)	(0.0801)
Tertiary				0.522***	0.397**	
				(0.127)	(0.123)	
Off farm employ't				-0.0505	-0.0373	-0.0103
				(0.0363)	(0.0355)	(0.0241)
Urban				0.481***	0.383***	-0.00217
				(0.0503)	(0.0475)	(0.0770)
Agro-ecologies						
Banana/coffee				0.441***	0.279***	0.0412
				(0.0777)	(0.0791)	(0.0403)
Banana/millet/cotton				0.172**	0.0152	0.0979**
				(0.0813)	(0.0825)	(0.0395)
Montane				0.273**	0.135*	0.0318
				(0.0843)	(0.0804)	(0.0388)
Teso				0.257**	0.223**	0.0341
				(0.109)	(0.110)	(0.0651)
Northern				0.00839	-0.0241	-0.0123
				(0.0867)	(0.0731)	(0.0450)
Pastoral				0.0424	0.212**	-0.206***
				(0.141)	(0.0905)	(0.0558)
Un weighted sample	5170	3893	1277	3241	2412	829
Weighted sample size	7,103,646	5,572,484	1,531,162	3,185,817	2,494,401	691,416
R^2	0.0414	0.046	0.014	0.312	0.299	0.091
Prob<F	0.000	0.000	0.0004	0.000	0.000	0.000

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

5.5.2.2 Heterogeneity in impacts of adaptation strategies by covariate shock on welfare

As earlier mentioned, the aggregated impact of coping strategies may mask individual grouped choice of adaptation strategies by shock on welfare. In addition, endogeneity between the vector of adaptation choice strategies by shock and level of household welfare needs to be addressed. In identifying the IV to use, we first test the individual validity and exogeneity of the instrumental variable using Hansen's J test (Davidson and

MacKinnon 2004).[34] In all cases, this test failed to reject the null hypothesis that the instrument (region) is valid and exogenous. Hence, we report results of reduced form models of equations, (5.1), (5.2) and (5.4) for both OLS and IV 2SLS on pooled data with underlying reasons for model choices as previously discussed.

Tables 5.8, 5.9, 5.10 and 5.11 present results by covariate shock at national level with increasing sophistication as per model formulation. Appendix C: Tables C.2, C.3, C.4 and C.5 present corresponding results controlling for the poverty status of the household. The Wooldridge's (1995) robust score test and a robust regression-based endogeneity test are presented in Appendix C: Tables C.6, C.7, C.8 and C.9. Throughout the analysis, the Huber-white standard errors clustered at the household level to control for heteroskedasticity in estimates is used.

Impact of vector of adaptation choice strategies employed during drought on welfare

Table 5.8 presents OLS and IV 2SLS national estimates for choice of adaptation strategies employed during drought and welfare. Appendix C: Table C.2 presents further analysis controlling for a household's poverty status. In Appendix C: Table C.6, the Wooldridge (1995) test rejects the null of exogeneity of variables for results in column (4) and (5) (Table 5.8) implying 2SLS produce unbiased and consistent estimates over

[34]Results are not shown. But to check this, we run reduced form regressions with an IV (region) as the explanatory variable and our troublesome explanatory variable (vector of coping strategies by shock) as the dependent variable (Murray, 2006).

OLS. However, the test fails to reject the null of exogeneity in variables for model (5.4) (see column 6) in Table 5.8, meaning OLS estimates are preferred to IV 2SLS estimates.

Thus, 2SLS findings (columns 4 & 5) reveal that coping strategies employed during droughts are bad for welfare of a household. That is they individually lead to a 51.7 percent loss in welfare and with robustness checks the welfare loss realised is about 25.8 percent. Similar findings are noted for both poor and non-poor households (see Appendix C: Table C.2). Denton (2002) argues that poverty leads to poor women and men unable to make choices that might improve their socio-economic status conditions in times of disasters. Agarwal (1990) takes this argument further and asserts that land rights could prove crucial during severe subsistence crises, as during drought and famine. In such contexts, households more especially poor rural households first dispose of assets such as jewellery, household utensils and small animals, keeping the productive resource –land – till the last. Such adaptation choices during calamities have negative implication on welfare.

Other controls included show that at the national level, household size leads to a welfare loss of 2.8 percent, education of the household head has a positive impact on welfare where if the head has secondary education welfare gains realised are 18.6 percent and increase further with a head who has tertiary education (60.3 percent) (Skoufias et al., 2011 and Di Falco et al., 2011 find similar results). Education represents a heads ability to access information on climate and adaptation and flexibility in the job market to attract better paying jobs (Deressa et al., 2008; Davies et al., 2008; Below et al., 2010). Furthermore, land tenure system implies that formal land ownership leads to welfare losses of 28.7 percent which is counter intuitive as we had expected the contrary. Insights from Di Falco et al. (2011) on land show that even in formal land holdings, if oral contracts and agreements predominate, then even formal land ownership leads to insecurity in the tenure system hence might not enhance welfare. However, given that a household has formal land ownership and took measures to cope during droughts leads to welfare gains of 6.7 percent.

In addition, as expected being located in urban areas has a positive impact on welfare of about 38 percent. Lastly, households located in Pastoral and WestNile agro ecologies have negative impact on welfare (43.2 percent and 33.9 percent respectively-Column 5). Inclusion of interaction terms maintains the result, that being located in any given agro ecology and a household took measure to cope during drought leads to welfare losses of 0.3 percent nationally. This points to a household's vulnerability in these zones in employing highly risky coping strategies (such as reducing food intake, selling of assets especially livestock at low prices as they are malnourished during drought) that reduce welfare (Di Falco et al., 2011).

Table 5.8: Pooled OLS and 2SLS estimates of impact of adaption to droughts on welfare

Log of welfare	(1) OLS All	(2) OLS All	(3) OLS All	(4) 2SLS All	(5) 2SLS All	(6) 2SLS All
Cope drought	-0.0304**	-0.0380**	-0.139	-0.517**	-0.258*	-2.722
	(0.0107)	(0.0125)	(0.107)	(0.160)	(0.148)	(3.557)
HH size		-0.0334***	-0.133		-0.0286**	-0.638
		(0.00858)	(0.121)		(0.00975)	(0.720)
Age head		0.000882	0.0223		0.00250	-0.165
		(0.00161)	(0.0200)		(0.00189)	(0.255)
Gender head		0.121**	-0.0161		0.0943	-1.987
		(0.0500)	(0.569)		(0.0591)	(2.754)
Education of head						
Secondary		0.156**	1.452*		0.186**	-4.945
		(0.0615)	(0.846)		(0.0708)	(8.836)
Tertiary		0.712***	3.252*		0.603**	-9.278
		(0.182)	(1.745)		(0.192)	(17.26)
Off farm emply't		-0.0128	-1.192*		0.0591	-11.81
		(0.0484)	(0.632)		(0.0758)	(14.77)
Land tenure system		-0.232***	-1.714**		-0.287***	-13.04
		(0.0546)	(0.721)		(0.0739)	(15.70)
Urban		0.401***	0.612		0.380**	-2.183
		(0.0911)	(1.818)		(0.125)	(4.997)
Agro-ecologies						
Banana/millet/cotton		-0.0299	-0.0719		-0.0367	0.0394
		(0.0724)	(0.0704)		(0.0839)	(0.182)
Montane		0.108	0.168**		0.116	0.270*
		(0.0731)	(0.0705)		(0.0852)	(0.162)
Teso		0.178	0.284**		-0.0831	0.470
		(0.127)	(0.127)		(0.203)	(0.294)
Pastoral		-0.317**	-0.0401		-0.432**	0.0746
		(0.133)	(0.158)		(0.165)	(0.193)
WestNile		-0.179**	0.127		-0.339**	0.0482
		(0.0647)	(0.121)		(0.127)	(0.162)
Interaction terms						
Gender*copdr			0.00517			0.0904
			(0.0244)			(0.119)
Agro-ecology* copdr			-0.00303**			-0.00125
			(0.00101)			(0.00263)
Urban*copdr			-0.0106			0.112
			(0.0757)			(0.217)
HH size*copdr			0.00409			0.0259
			(0.00507)			(0.0310)
Off farm *copdr			0.0512*			0.516
			(0.0278)			(0.647)
Land tenure*copdr			0.0669**			0.549
			(0.0305)			(0.669)
Age HH*copdr			-0.000931			0.00719
			(0.000855)			(0.0111)
Education HH*copdr			-0.0554			0.223
			(0.0362)			(0.384)
Un weighted sample	2,025	1,206	1,206	2,025	1,206	1,206

Weighted sample size	2,645,835	1,258,942	1,258,942	2,645,835	1,258,942	1,258,942
R^2	0.006	0.161	0.186	.	.	.
Prob>F	0.0054	0.000	0.000	0.0016	0.000	0.000

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Impact of vector of adaptation choice strategies employed during floods on welfare

Presented in Table 5.9 are OLS and IV 2SLS model estimates for the impact of choices of adaptation strategies employed on welfare during floods. Additional analysis controlling for a household's poverty status is provided in Appendix C: Table C.3. While a summary of the Wooldridge's (1995) exogeneity test results are in Appendix C: Table C.7. The tests reject the null hypothesis of exogeneity of variables for 2SLS results in column (4) and (5) but not column (6). Thus, we interpret results of OLS column (3) and 2SLS estimates in columns (4) and (5).

From Table 5.9, we find that the individual impact of the vector of adaptation strategies employed during floods show a positive impact on welfare (44.6 percent welfare gain). However, when we control for household characteristics and climate indicators fixed effects, the impact reverse where a 60.7 percent loss is realised with the nature of adaptation strategies employed during floods (these include mainly scaling back meals and increasing labour supply) also significant findings are noted for non-poor households (Appendix C: Table C.3).Some households in specific regions depend entirely of emergency aid from government, Humanitarian organisations and social networks. As accentuated by Heltberg and Lund (2009) and Thomas et al. (2010), such basic facts suggest that, although private and government assistance is possible and being implemented, there are limits to its effectiveness in helping households cope with risk hence adaptation strategies taken have negative implications of welfare in the long run.

We also find that the form of land tenure ownership increases welfare losses of about 45 percent for households with formal land ownership. Similar arguments hold as those made during drought. The impact of being located in the Teso agro-ecological climate zone is bad for welfare during floods. Such a finding corresponds to actual flood occurrence statistics frequent and persistent in this agro ecological zone and household/individuals rely on relief support and safety nets when their homes, roads and crops are destroyed (various reports FEWSNET; UNAPA, 2007).

Table 5.9: Pooled OLS and 2SLS estimates of impact of adaptation during floods on welfare

Log of welfare	(1) OLS All	(2) OLS All	(3) OLS All	(4) 2SLS All	(5) 2SLS All	(6) 2SLS All
Cope floods	0.0296	-0.00454	-0.00707	0.446**	-0.607*	-3.796
	(0.0181)	(0.0187)	(0.241)	(0.151)	(0.326)	(3.924)
Gender head		0.103	0.0758		0.0643	-27.12
		(0.101)	(1.342)		(0.178)	(28.07)
Age head		0.00167	0.0365		-0.00134	-0.998
		(0.00229)	(0.0328)		(0.00484)	(1.075)
Education head						
Secondary		0.106	1.482		-0.234	
		(0.111)	(1.381)		(0.291)	
Tertiary		0.327	3.150		-0.00326	
		(0.308)	(2.759)		(0.478)	
Land tenure system		-0.144	-0.476		-0.450*	
		(0.0945)	(1.781)		(0.277)	
HH size		-0.0306**	-0.455**		-0.0333	-2.924
		(0.0128)	(0.225)		(0.0273)	(2.676)
Urban		0.231	0.166		0.709	0.659
		(0.253)	(0.275)		(0.471)	(0.560)
Agro-ecologies						
WestNile		-0.108	0.159		-0.312	0.455
		(0.115)	(0.162)		(0.358)	(0.549)
Pastoral		-0.219**	-0.00801		-0.592	-0.244
		(0.110)	(0.145)		(0.368)	(0.481)
Teso		-0.346**	-0.295**		-1.065**	-0.369
		(0.124)	(0.113)		(0.430)	(0.381)
Banana/millet/cotton		-0.118	-0.231*		-0.487	-0.163
		(0.139)	(0.133)		(0.312)	(0.252)
Interaction terms						
Gender *copflood			0.000804			1.192
			(0.0613)			(1.229)
Age HH*copflood			-0.00156			0.0437
			(0.00145)			(0.0470)
Educ HH*copflood			-0.0621			
			(0.0613)			
Land tenure*copflood			0.0205			
			(0.0793)			
HH size* copflood			0.0189*			0.129
			(0.00998)			(0.120)
Agro-ecology* copflood			-0.00374**			-0.00322
			(0.00144)			(0.00316)
Un weighted sample	366	306	306	366	306	366
Weighted sample size	302,300	230,947	230,947	302,300	230,947	230,947
R^2	0.007	0.093	0.133	.	.	.
Prob>F	0.1065	0.0004	0.0001	0.0041	0.0952	0.1465

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Impact of vector of adaptation choice strategies employed during crop pest attacks on welfare

Table 5.10 displays results of OLS and IV 2SLS model estimates for equations (5.1), (5.2) and (5.4) for the impact of adaptation choice strategies utilised during crop pest attack on welfare. We further distinguish between households that are poor and non-poor where the extra results by poverty status are displayed in Appendix C: Table C.4. To validate our analysis of model choice, a summary of the Wooldridge's (1995) exogeneity test results are presented in Appendix C: Table C.8. From the tests, we interpret OLS estimates of columns (2), (3) and IV 2SLS results of column (4) of Table 5.10.

We find that choice of adaptation strategies employed during cop pests attacks mainly through use of agricultural technologies (changing of seed varieties, use of pesticide and insecticide) seem to lead to welfare gains of 34.4 percent (Table 5.10, column (4)). The welfare gain was even significant among poor households (30.4 percent) who took coping measures during crop pest attacks (Appendix C: Table C.4, column (10)). When we control for household characteristics and agro-ecological zones (Table 5.10, column (2)), the impact of coping choices taken during crop pest attacks are no longer significant.

However, household located in urban areas have a positive impact on welfare of 52.8 percent while farm size and the level of insecurity still in the formal nature of land ownership lead to welfare losses of 0.6 percent and 26.2 percent respectively. Inclusion of interaction terms show that households located in the Montane, Teso and Banana/Coffee agro-ecological climate zones had positive impacts on welfare. This could be attributed to the higher returns in agricultural incomes associated with activities taking place in these agro-ecologies especially in the Banana/Coffee and Montane zones- where coffee is Uganda's leading cash crop export earner and banana the most commonly domestically consumed food crop (UBoS various reports).

Table 5.10: Pooled OLS and 2SLS estimates of impact of adaptation during crop pests on welfare

Log of welfare	(1) OLS All	(2) OLS All	(3) OLS All	(4) 2SLS All	(5) 2SLS All	(6) 2SLS All
Cope pests	0.0192	-0.0276	-0.0200	0.344*	-0.154	-0.167
	(0.0362)	(0.0419)	(0.249)	(0.192)	(0.197)	(1.143)
Gender of head		0.0463	0.308		0.0435	0.284
		(0.133)	(2.141)		(0.145)	(3.000)
Age head		-0.00119	0.0402		0.00102	0.0241
		(0.00300)	(0.0408)		(0.00404)	(0.159)
Education head						
Primary		0.0151	0.235		0.0739	0.279
		(0.115)	(0.263)		(0.151)	(0.709)
HH size		-0.00338	0.0474		-0.00822	-0.0586
		(0.0125)	(0.265)		(0.0163)	(0.713)
Urban		0.528**	0.535**		0.519**	0.529**
		(0.217)	(0.225)		(0.229)	(0.233)
Farm size		-0.00633**	-0.0804		-0.00627**	-0.124
		(0.00195)	(0.277)		(0.00194)	(0.253)
Land tenure system		-0.262*	-0.770		-0.350*	-2.521
		(0.135)	(2.188)		(0.195)	(7.729)
Agro-ecologies						
WestNile		-0.0272	-0.734		0.0656	-0.170
		(0.221)	(0.456)		(0.245)	(0.417)
Montane		-0.0178	0.848*			
		(0.138)	(0.515)			
Teso		0.168	0.695**		0.131	0.230
		(0.183)	(0.318)		(0.194)	(0.217)
Banana/millet/cotton		-0.115	1.122		-0.132	-0.00170
		(0.180)	(0.755)		(0.183)	(0.197)
Banana/coffee		0.0307	1.660*		0.0609	0.173
		(0.136)	(0.998)		(0.143)	(0.257)
Interaction terms						
Gender*coppest			-0.0113			-0.0117
			(0.0951)			(0.128)

Age HH*coppest			-0.00177			-0.00107
			(0.00172)			(0.00692)
Edud HH*coppest			0.00818			0.00973
			(0.00842)			(0.0253)
HH size*coppest			-0.00225			0.00251
			(0.0118)			(0.0315)
Farm size*coppest			0.00341			0.00535
			(0.0126)			(0.0115)
Land tenure*coppest			0.0220			0.0985
			(0.0955)			(0.338)
Agro-ecology*coppest			0.0167			0.00193
			(0.0102)			(0.00388)
Un-weighted sample	300	231	231	300	231	231
Weighted sample size	301,932	209,796	209,796	301,932	209,796	209,796
R^2	0.002	0.165	0.193	.	0.095	0.178
Prob>F	0.5974	0.0089	0.0378	0.0768	0.0270	0.0216

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Impact of vector of adaptation choice strategies employed during livestock epidemics on welfare

Table 5.11 and Appendix C: Table C.5 present OLS and IV 2SLS general estimates and poverty status respectively. Appendix C: Table C.9 displays summary Wooldridge's (1995) robust score exogeneity tests for all our models. Based on the tests, we interpret estimates in Table 5.11, columns (2) and (3) and IV 2SLS estimates in column (4).

The result in column (4) shows that choice of adaptation strategies employed during livestock epidemics improves welfare significantly. Especially because households indicate to increasingly use their savings as they sell their asset-livestock during epidemics. But as Helterg and Lund (2009) note, improving welfare in this format usually has a once off shock in welfare gains that are difficult to maintain in the long-run if the epidemics become more persistent.

Table 5.11: Pooled OLS and 2SLS estimates of impact of adaptation during livestock epidemics on welfare

Log of welfare	(1) OLS All	(2) OLS All	(3) OLS All	(4) 2SLS All	(5) 2SLS All	(6) 2SLS All
Cope livestock epidemic	0.0557	0.0292	0.785**	1.102*	0.505	4.142
	(0.0582)	(0.0558)	(0.326)	(0.659)	(0.982)	(4.702)
Gender head		-0.0862	4.577		-0.0858	14.62
		(0.147)	(3.083)		(0.167)	(14.39)
Age head		-0.00230	0.0658		-0.000691	0.466
		(0.00304)	(0.0658)		(0.00603)	(0.574)
HH size		-0.0335*	0.420		-0.0898	2.618
		(0.0194)	(0.481)		(0.117)	(3.127)
Urban		0.480***	2.925		0.640	-0.581
		(0.129)	(4.272)		(0.404)	(6.571)
Land tenure		-0.332**	3.886		-0.491	23.25
		(0.116)	(3.012)		(0.331)	(27.12)
Agro-ecologies						
WestNile		-0.205	-0.460		-0.197	-0.111
		(0.248)	(0.828)		(0.449)	(1.385)
Northern		-0.190	-0.353		-0.0116	-0.197
		(0.143)	(0.531)		(0.429)	(0.850)
Pastoral		-0.0366	-0.250		-0.0837	-0.236
		(0.213)	(0.692)		(0.220)	(0.915)
Teso		-0.0384	-0.140		-0.192	0.00271
		(0.162)	(0.406)		(0.399)	(0.696)
Banana/millet/cotton		0.262	0.216		0.517	0.0942
		(0.259)	(0.263)		(0.579)	(0.367)
Interaction terms						
Gender*coplivestock			-0.207			-0.653
			(0.139)			(0.638)
Age HH*coplivestock			-0.00303			-0.0208
			(0.00292)			(0.0254)
HH size*coplivestock			-0.0199			-0.117
			(0.0214)			(0.139)
Urban*coplivestock			-0.112			0.0338
			(0.192)			(0.283)
Land tenure*coplivestock			-0.187			-1.043
			(0.136)			(1.198)
Agroecology*coplivestock			0.00186			-0.000665
			(0.00630)			(0.0103)
Un-weighted sample	140	123	123	140	123	123
Weighed sample size	142,264	125,176	125,176	142,264	125,176	125,176
R^2	0.010	0.182	0.225	.	.	.
Prob>F	0.3426	0.0002	0.0022	0.0998	0.0330	0.0048

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

We also note the differences in coefficients and signs when more controls and interaction terms are factored in, for the general model and especially for poor households (Appendix C: Table C.5). That is poor households who took adaptation measures during livestock epidemics realise welfare loses of 4.5 percent with household size and land tenure system and households located in the WestNile and Pastoral agro ecologies who are poor having welfare losses as well (Appendix C: Table C.5, column (4)). Asset ownership is limited almost non-existent in extremely poor households resorting to adaptation strategies that lead to further vulnerability of the household during disasters (Agarwal, 1990; Deere and Doss, 2008). Given the communal nature of households involved in livestock farming, any disease outbreak affects several other kraals (grazing on communal land) leading to more than 50 percent welfare loss in the event of a livestock epidemic occurring.

5.6 Conclusion

The objective of this chapter is to analyse the impact of collective choices of adaptation strategies employed to climate change induced shocks on welfare and further investigate the welfare implications of these choices for poor and non-poor households. Utilised is a panel of 2,566 original households that are covered in the surveys of 2005/06 and 2009/10 and apply OLS and IV 2SLS estimators on pooled data. Wooldridge's (1995) robust score test is performed to help in model choice for interpretation. Findings and insights from our discussions show that choices of adaptation strategies for each covariate shock analysed in our study have differential impacts on household welfare.

Specifically, aggregated impacts of choices of adaptation strategies employed by shock on welfare show that strategies employed during droughts and floods impact negatively on welfare even for the non-poor households. However, coping measures employed during livestock epidemics lead to improvement in household welfare especially for poor households. Further, inclusion of controls such as household characteristics and climate fixed level effects (agro-ecologies) yield novel insights. Of note is that household size and land tenure system have negative impacts on welfare.

Heterogeneity in welfare impacts as a result of choice of adaptation strategies employed for each shock is noted. Implications of such findings are that not all coping mechanisms undertaken during natural disaster directly translate into improved household well-being. Many of the adaptation strategies employed by households during shocks such as scaling back consumption, sale of assets to increase savings and increase labour supply potentially further increase household vulnerability. Implying, even after the disasters, household recovery is slow, that is, if they recover at all. Such findings allude to the importance of asset ownership more especially security of the single most important asset to Ugandans, land. Many a time, safety nets that are provided for example during floods and land/mud slides cease prior to household full recovery from disasters. The policy implication here is that, public action is needed to help households cope, through better access to formal and non-exploitative coping strategies such as easier access to credit with less stringent interest rates and collateral to enable household better insure against risks.

CHAPTER SIX

CONCLUSION AND POLICY IMPLICATIONS

6.1 Introduction

Discussed in this chapter are the conclusions drawn from the study. Specifically, Sections 6.2 summaries major findings of the study, Section 6.3 provides the policy implications emerging from the study findings and Section 6.4 highlights the limitations of the study further providing suggestions for areas of future research.

6.2 Summary of study findings

The study's broad objective was to assess the implication of adaptation to climate variability and change in Uganda, particularly, delving into a gender perspective and household welfare implications that arise from adaptation choices employed. First, the study sets out to establish and explore the extent climate is varying and changing in Uganda.

Explicitly, a review of laws and policies is discussed in Chapter Two. Specifically, a critical review of the current working laws and policies and the extent to which they address climate change issues, welfare and gender is done. The review notes that indeed laws and some policies do recognise climate change in their agendas, however, the mode of implementation and enforcement is just on paper. Almost all laws and policies discuss and include gender just in passing hence become largely gender neutral or in other cases even gender blind. For emphasis, implementation of climate change and engendering policies and laws is not well developed, as a result, enforcement and in addition, implementation of gender and climate change issues in policies by institutions concerned is limited and in some cases non-existent. We acknowledge that, majority of these laws and policies were written at the time when climate change was not a serious matter on policy agendas. Thus, a separate standalone climate change policy is a prerequisite to monitor climate change interests in other policy frameworks. It should clearly map out the role of every Ugandan, male and female, boys and girls to ensure active participation, avenues for financial mobilisation to finance its implementation should be explored and included.

Chapter Three sought to assess and empirically analyse the extent of climate change in Uganda. Measures for climate variability and change are identified for analysis (temperatures and rainfall). Data used are gathered by UDoM from 13 weather stations across the country, categorised by homogenous climate zones. In addition, data on monthly LTM rainfall totals (mm) and standardising data over 30 year period annual average minimum and maximum temperature and annual rainfall totals to calculate anomalies are utilised to calculate climate change in climate indicators. Graphical analysis was utilised throughout the discussions. Results from the LTM comparisons and anomalies show that climate change is occurring in Uganda. In particular, climate change is observed from the altered rainfall, temperatures and onset and cessation of rainfall patterns from natural climate variability expectations. Further comparisons with the ENSO and SSTs show that the frequent and persistent droughts and floods experienced and affecting many Ugandans especially agricultural households are resulting from observed changes in climate conditions globally. These have implications on the nature of adaption, gender implications in their impact and welfare.

Chapter Four set out to document the types and frequency of shocks households were reporting due to climate change induced events. Choices of adaptation strategies to shocks employed by households with a gender perspective are analysed. We go further and use the MNL model on pooled panel data for 2,566 households, to empirically identify factors that lead to the decision among male and female headed households choice of adaptation strategies employed for each actual shock reported. The IIA Hausman-McFadden test is used to validate our model specification. The findings reveal, at least more than a third of the sampled households experience more than one type of shock. Empirical results indicate that choices of adaptation strategies to covariate shocks are similar in both female headed households (FHHs) and male headed households (MHHs) but factors influencing the responses are not gender neutral. Coping strategies to covariate shocks reported by households are “last-resort” or “impromptu” responses, largely behavioural, hence informal in nature and ad-hoc. Specifically, survey findings show that FHHs reduce consumption while MHHs utilise savings and reduce consumption during droughts. Faced with livestock epidemics, MHHs use savings and FHHs provide more labour as coping strategies. Use of agricultural related technology and increased labour supply was higher during crop pests and disease outbreaks regardless of gender of the household head.

Our control variables such, as age of the household head, distance to markets, land tenure system, area of residence, region, off-farm employment and agro ecological zones are key factors influencing choice of adaptation strategies for FHH and MHHs but likelihood of importance in some cases differs. For instance, agro ecological zones play a key role in adaptation strategies taken for FHHs and MHHs reflecting the relative importance of not only of indigenous knowledge and externalities in climate change adaptation but also ingrained social and cultural norms across groups. MHHs, who had some employment off the farm during drought, are better off (do not reduce consumption). For FHHs, land tenure system (customary) is negatively associated with adaptation during drought however it's vice versa for MHHs. In some instances such as during livestock epidemics, results show a negative effect of land tenure system with adaptation strategies for MHHs.

Chapter Five, analysed the impact of choices of adaptation strategies employed during climate distress events on household welfare. Further disaggregated are welfare impacts of adaptation choice strategies for poor and non-poor households. We utilized the same data set as in Chapter Four but now apply OLS and IV 2SLS estimators on pooled data. In addition, the Wooldridge's (1995) robust score test utilised to estimate exogeneity in variables for the IV 2SLS estimator and further aids us in model choice. Descriptive analysis indicates that heterogeneity in the mean welfare distribution improved from UShs.66,821 in 2005/06 to Ushs.76,069 in 2009/10 and at the median welfare improved from Ushs.48,429 to Ushs.50,682 over the same period (corresponding to a 4.7 percent increase in welfare). While empirical analysis for aggregated impacts of choices of adaptation strategies employed by shock on welfare show that strategies employed during droughts and floods impact negatively on welfare even for the non-poor households. However, coping measures employed during livestock epidemics lead to improvement in household welfare especially for poor households. Further, inclusion of controls such as household characteristics and climate fixed level effects yield novel insights such as household size and land tenure system having negative impacts on welfare. Heterogeneity in welfare impacts as a result of choice of adaptation strategies employed for each shock is observed, specifically, in the disaggregated poor and non-poor households.

6.3 Policy implications

Findings suggest that (1) policy makers should review and rewrite some of the laws and policies that link and address gender and climate change, further, foster resilience of households to cope with climate change. This can be in form of strengthening and enforcing laws that protect women's rights and generally poor people in accumulation of assets, increase off-farm jobs even for the uneducated people during crisis, and enforcement of the land rights law especially women rights on arable land. (2) Government policies addressing climate change should identify and implement adaptation options for each unique climate distress event that reduce vulnerability of women and men in times of crisis. This may take the form of timely food aid, food subsidies or other programmes that offer safety nets to households more vulnerable to climate shocks (3) Increase advocacy where households should be encouraged to increase food piles e.g. through drying of fruit and vegetables in times of bumper harvests to be used during poor production years and improve food storage facilities like granaries. And lastly, (4) Government and development partners needs to invest in irrigation schemes to not only harvest excess rain water during floods but to act as reservoirs during drought in the long run. This will reduce household vulnerability in food availability and security when climate change induced shocks occur.

Generally, government and the public should endeavour to take climate policy implementation more seriously other than having beautiful policies on paper which are cannot be enforced in the short and long run due to lack of technical capacity, finance and equipment to foster the implement process.

6.4 Limitations of the study and possible areas for further research

- The Uganda National Panel Survey is a 7 year panel such that new research can update their databases with new rounds of surveys and estimate dynamic panels to further understand and estimate persistence in adaptation choices employed.

- Analyse the split off households can be incorporated for those interested in unbalanced panels and who are interested in noting behaviour patterns for split-off households.
- Another study can specifically analyse and map vulnerability for households that adapted to climate change induced shocks.
- Other studies can also venture into estimating all household shocks both covariate and idiosyncratic shocks coping strategy impacts on welfare in Uganda.
- Given that our data used is not exclusively gathered with climate change in mind, individuals with large budgets enough time can carry out their own panel survey with focus only on climate indicators and incorporate both the qualitative and quantitative analyses that no research using panel data has done. This study focuses on the quantification point of view.

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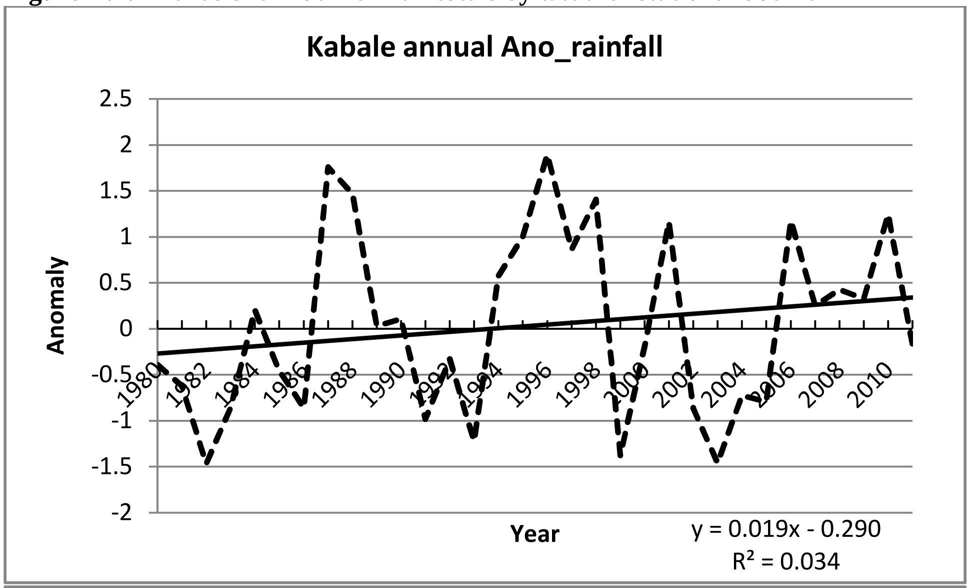
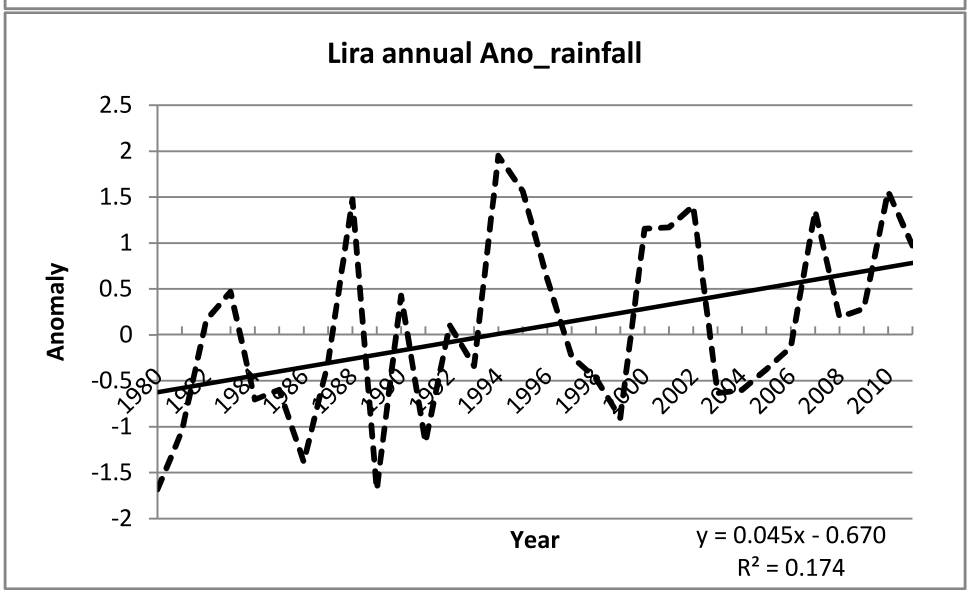
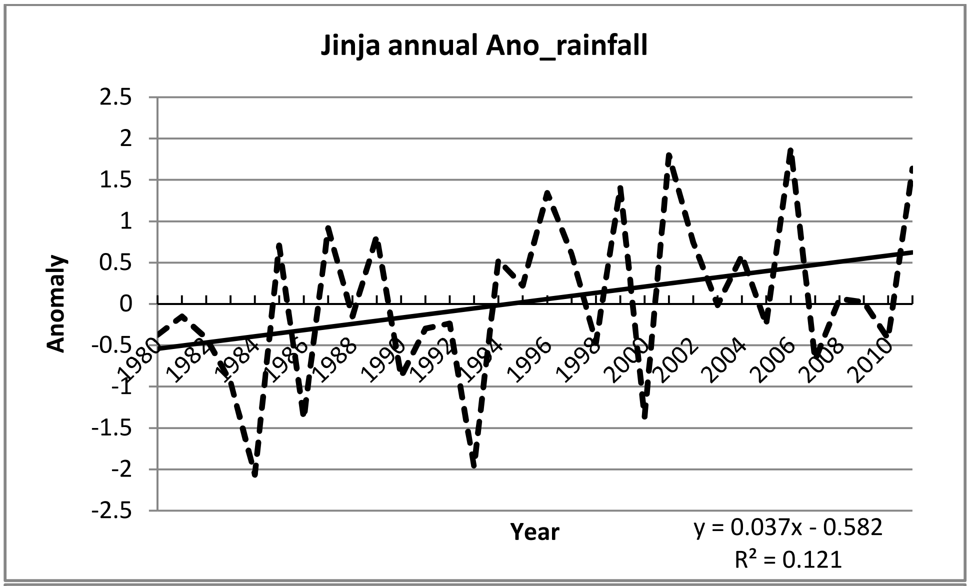
APPENDIX

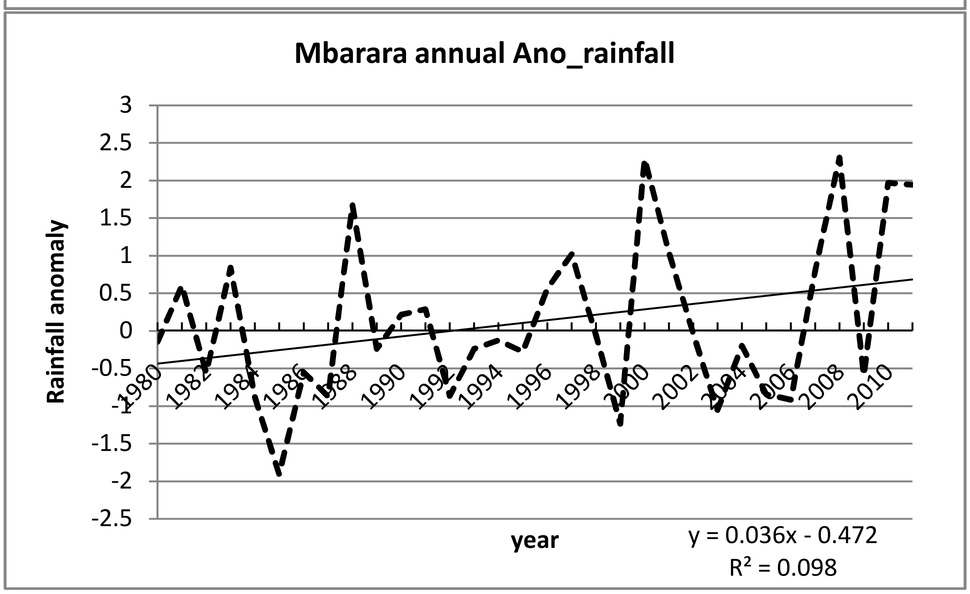
Appendix A: Additional Chapter 3 results

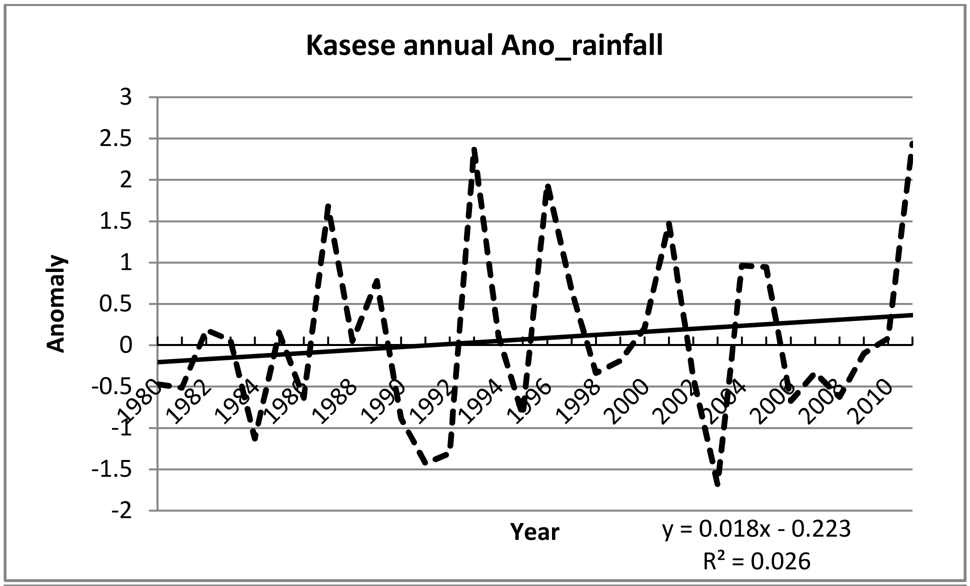
Figure A.1: Trends of annual rainfall totals by weather station: 1980-2011

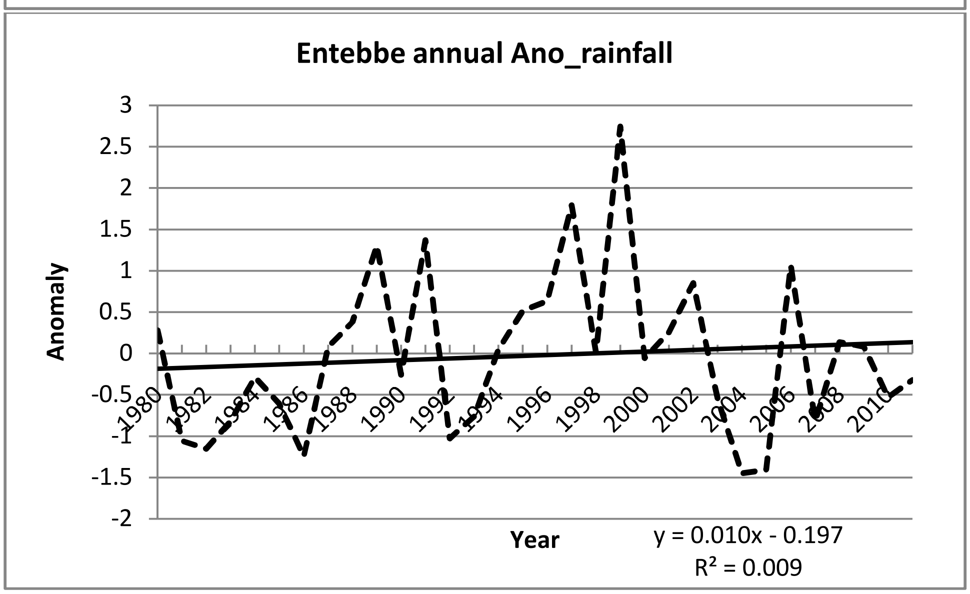


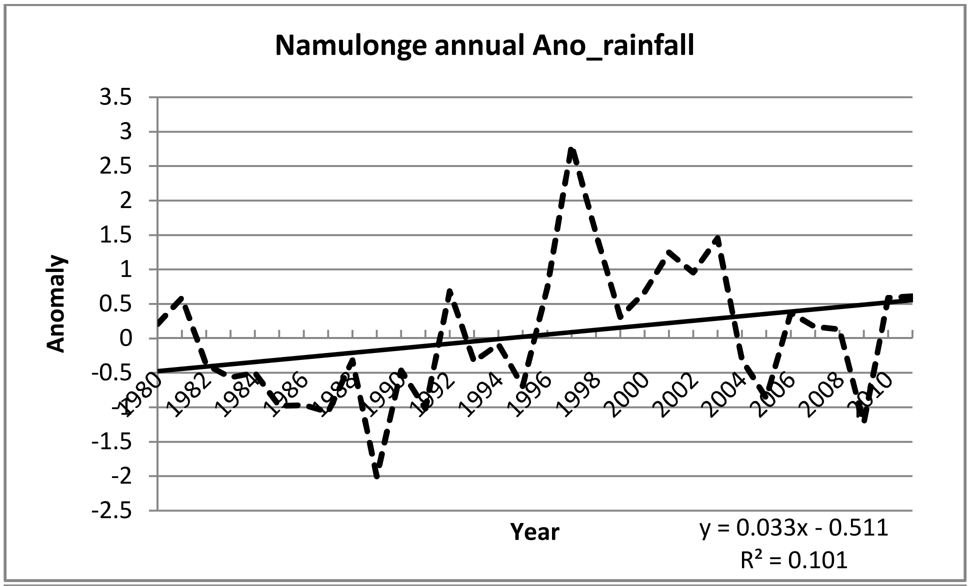


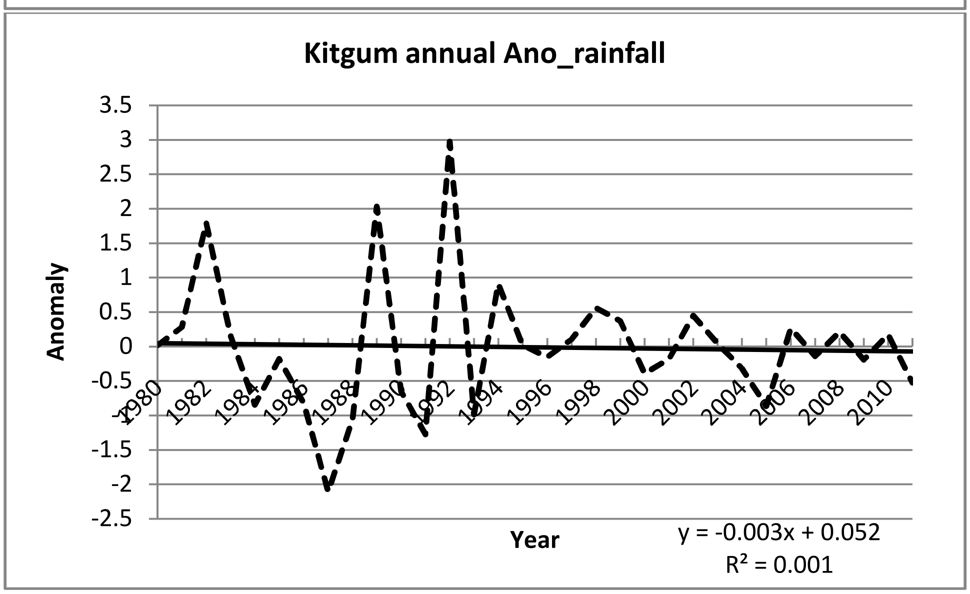

Jinja annual Ano_rainfall
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Anomaly
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
y = 0.037x - 0.582
R² = 0.121

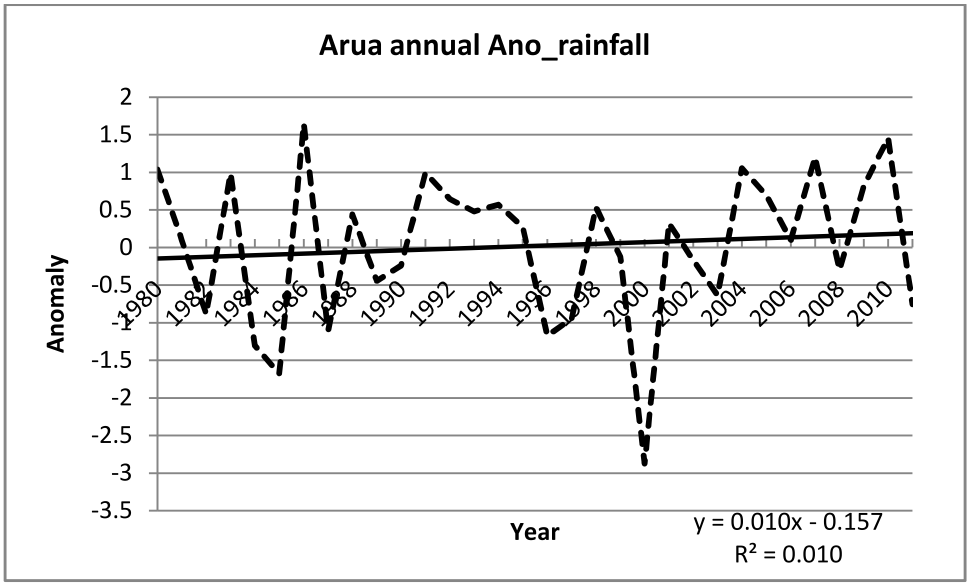

Mbarara annual Ano_rainfall
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Rainfall anomaly
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
year
y = 0.036x - 0.472
R² = 0.098


Kasese annual Ano_rainfall
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Anomaly
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
y = 0.018x - 0.223
R² = 0.026


Entebbe annual Ano_rainfall
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
Anomaly
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
y = 0.010x - 0.197
R² = 0.009

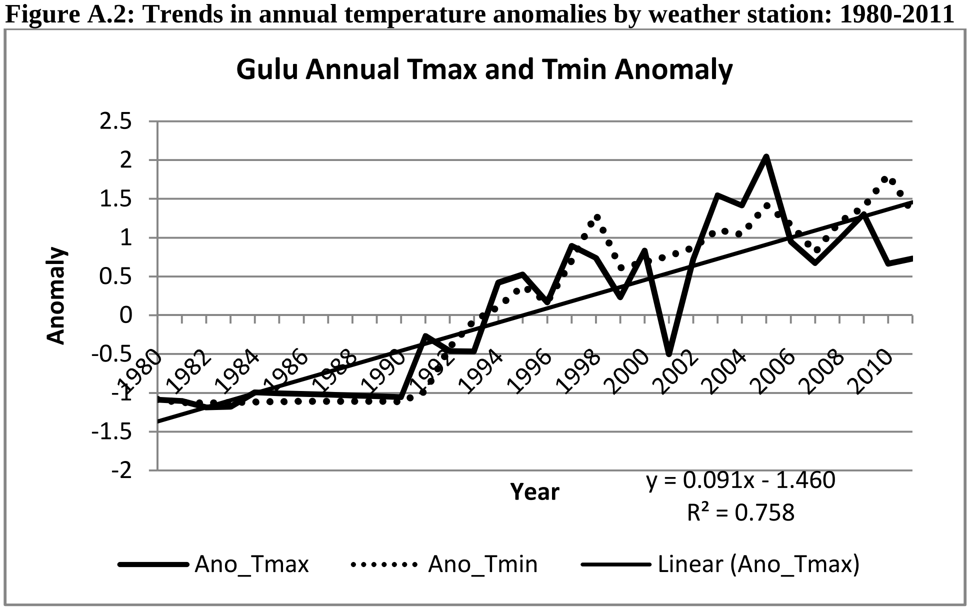

Namulonge annual Ano_rainfall
Anomaly
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
y = 0.033x - 0.511
R² = 0.101

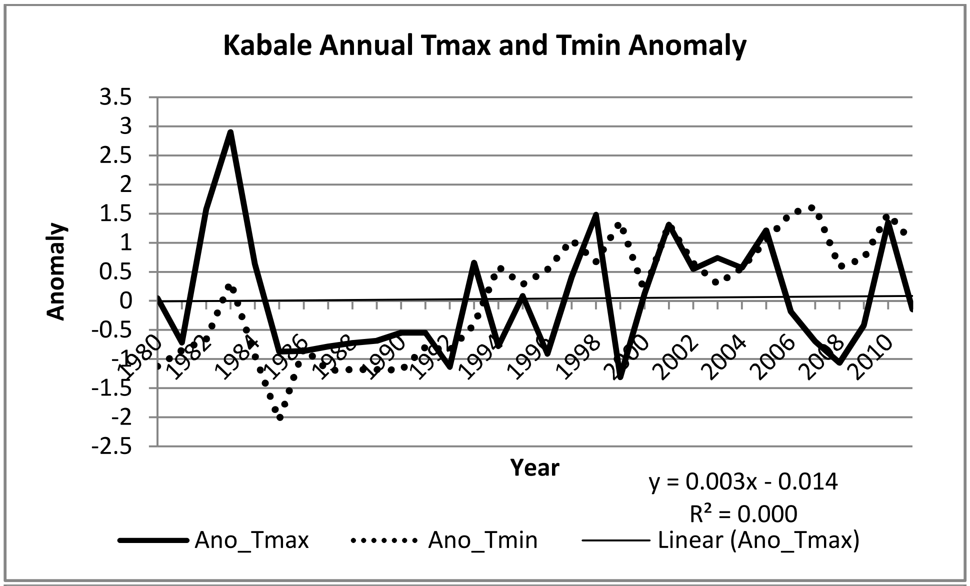

Kitgum annual Ano_rainfall
Anomaly
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
y = -0.003x + 0.052
R² = 0.001

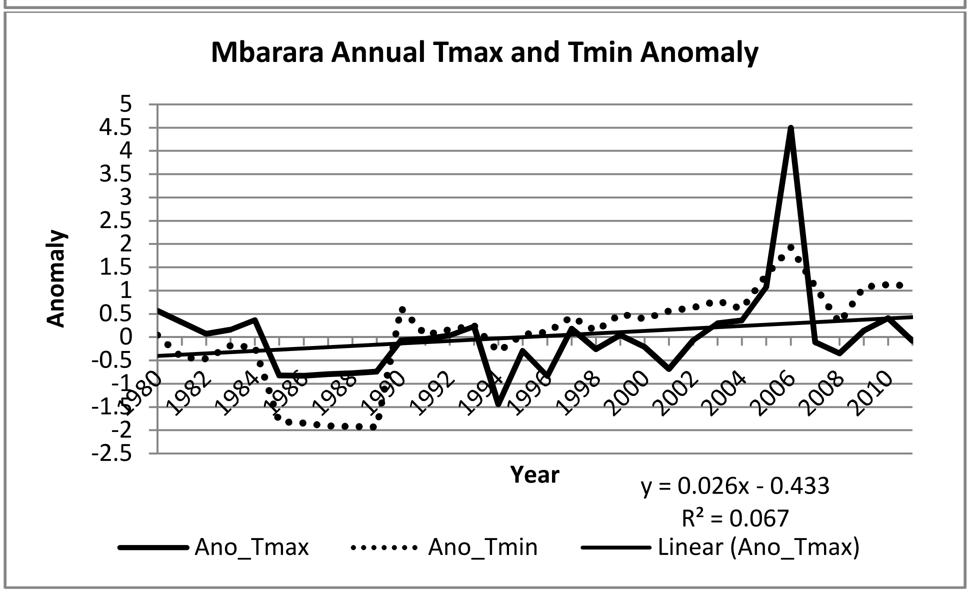


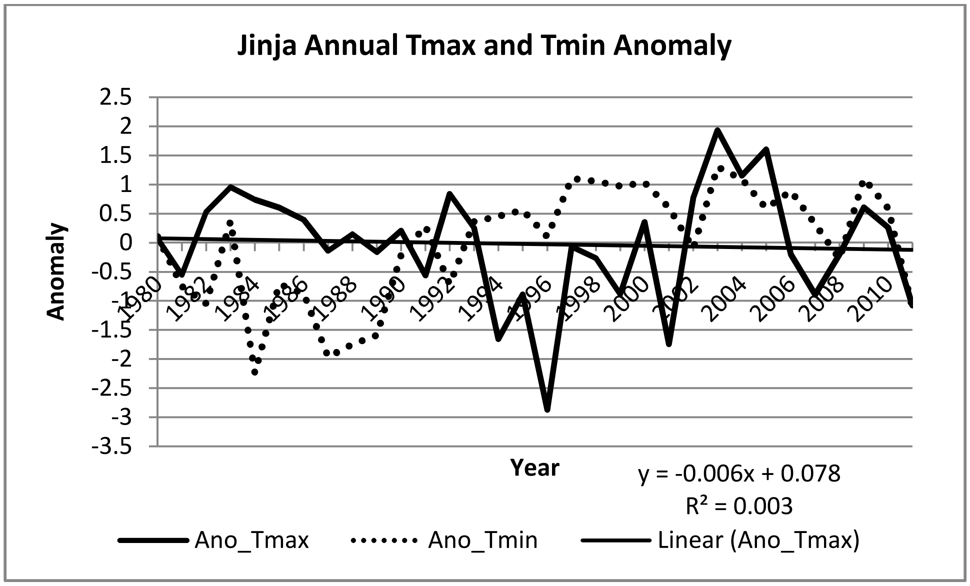
Source: Authors own based on Meteorological Data, MoWE, 2012

Figure A.2: Trends in annual temperature anomalies by weather station: 1980-2011




Kabale Annual Tmax and Tmin Anomaly
Anomaly
Year
y = 0.003x - 0.014
R² = 0.000
Ano_Tmax
Ano_Tmin
Linear (Ano_Tmax)


Mbarara Annual Tmax and Tmin Anomaly
Anomaly
Year
y = 0.026x - 0.433
R² = 0.067
Ano_Tmax
Ano_Tmin
Linear (Ano_Tmax)



Source: Authors own based on data from Meteorological Unit, MoWE, 2012

Appendix B: Additional Chapter 4 results

Table B.1: Coping mechanism by region and type of shock

			2005/06							
	Drought					Floods				
	Central	Eastern	Northern	Western	All	Central	Eastern	Northern	Western	All
Borrowing	0.4	0.4	0.4	2.5	3.8					
Labour sup	2.6	5.6	13.2	3.2	24.7	0.9	8.1	9.4	5.2	23.5
Technology	1.2	0.3	2.5	0.4	4.4	1.9	3.2	2.3	1.1	8.4
Savings	6.2	9.8	6.2	16.4	38.6	5.0	7.1	5.2	21.3	38.5
Reduce cons	8.9	4.0	10.1	5.5	28.5	4.3	4.0	6.6	8.6	23.5
	Pests					Livestock Epidemics				
	Central	Eastern	Northern	Western	All	Central	Eastern	Northern	Western	All
Borrowing	0.4	0.0	0.2	0.6	1.1	0.0	0.0	1.2	1.0	2.2
Labour sup	2.2	5.1	8.3	3.6	19.4	5.2	11.6	17.8	1.1	35.6
Technology	12.8	8.3	7.2	12.0	40.3	5.1	4.4	0.4	1.3	11.2
Savings	8.4	5.0	4.1	3.5	21.0	14.7	14.7	14.8	3.7	47.8
Reduce cons	8.3	2.2	4.5	3.1	18.2	0.0	1.2	1.9	0.0	3.1
			2009/10							
	Drought					Floods				
	Central	Eastern	Northern	Western	All	Central	Eastern	Northern	Western	All
Borrowing	0.7	0.0	0.2	0.9	1.8	0.0	0.0	0.0	0.0	0.0
Labour sup	4.3	3.9	10.0	1.9	20.0	2.7	11.4	11.3	0.0	25.4
Technology	1.6	1.9	1.3	0.5	5.2	0.0	2.7	2.7	0.0	5.4
Savings	11.6	2.8	5.4	5.6	25.4	0.0	4.4	1.9	11.7	18.0
Reduce cons	7.7	6.2	16.1	17.5	47.5	19.3	20.4	1.9	9.5	51.1
	Pests					Livestock Epidemics				
	Central	Eastern	Northern	Western	All	Central	Eastern	Northern	Western	All

Borrowing	2.7	0.0	0.0	1.8	4.5	0.0	0.0	0.0	0.0	0.0
Labour sup	3.6	6.2	0.0	0.0	9.8	9.9	0.0	0.0	0.0	9.9
Technology	10.3	9.1	1.0	0.8	21.2	3.5	3.2	0.0	0.0	6.7
Savings	25.0	0.4	0.0	1.5	26.9	40.8	27.1	3.3	2.9	74.1
Reduce cons	21.5	8.3	0.8	6.9	37.6	5.0	4.4	0.0	0.0	9.4

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.2: Coping mechanism by gender of household head and access to extension services

	2005/06									
	Drought					Floods				
	Female Head		Male Head			Female Head		Male Head		
Coping strategy	Extension	No Extension	Extension	No Extension	All	Extension	No Extension	Extension	No Extension	All
Borrowing	0.0	1.0	0.4	2.9	4.3	0.0	1.7	0.0	3.9	5.6
Labour supply	0.7	6.3	0.5	16.7	24.1	0.0	4.9	1.2	18.2	24.3
Technology	0.4	1.0	0.1	3.2	4.7	0.5	2.0	0.4	5.4	8.3
Savings	0.5	6.6	3.5	28.5	39.1	0.4	4.6	1.3	32.2	38.4
Reduce consumption	0.6	7.0	2.1	18.1	27.8	0.0	1.9	1.7	19.8	23.4
	Pests					Livestock Epidemic				
	Female Head		Male Head			Female Head		Male Head		
	Extension	No Extension	Extension	No Extension	All	Extension	No Extension	Extension	No Extension	All
Borrowing	0.0	0.9	0.0	0.0	0.9	0.0	0.0	1.2	1.3	2.6
Labour supply	0.3	5.5	0.9	14.2	20.8	0.0	11.5	1.2	23.0	35.7
Technology	1.4	3.7	5.8	27.9	38.9	0.0	1.9	1.1	8.9	11.8
Savings	0.0	3.5	2.8	14.7	20.9	3.0	7.5	3.6	32.2	46.3
Reduce consumption	0.0	3.9	0.0	14.6	18.5	0.0	1.4	0.0	2.2	3.6

	2009/10									
	Drought					Floods				
	Female Head		Male Head			Female Head		Male Head		
	Extension	No Extension	Extension	No Extension	All	Extension	No Extension	Extension	No Extension	All
Borrowing	0.2	0.2	0.3	0.7	1.4	0.0	0.0	0.0	0.0	0.0
Labour supply	0.5	4.0	2.8	13.0	20.4	0.0	5.2	0.0	22.3	27.5
Technology	0.0	1.5	0.9	3.6	5.9	0.0	0.0	3.4	3.4	6.9
Savings	1.0	4.6	4.1	13.3	23.0	0.0	4.1	0.0	8.0	12.1
Reduce consumption	1.3	13.3	5.2	29.6	49.3	0.0	22.6	5.6	25.3	53.5
	Pests					Livestock Epidemics				
	Female Head		Male Head			Female Head		Male Head		
	Extension	No Extension	Extension	No Extension	All	Extension	No Extension	Extension	No Extension	All
Borrowing	0.0	0.0	0.0	5.1	5.1	0.0	0.0	0.0	0.0	0.0
Labour supply	0.0	5.8	0.0	5.5	11.2	0.0	0.0	0.0	11.9	11.9
Technology	0.0	8.7	0.0	13.7	22.4	0.0	0.0	0.0	8.1	8.1
Savings	0.0	1.7	8.1	13.3	23.1	3.8	2.3	4.7	64.0	74.7
Reduce consumption	1.1	9.2	5.3	22.4	38.1	0.0	0.0	5.3	0.0	5.3

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.3: Coping mechanism by gender of household head and access to credit services

	2005/06									
	Drought					Floods				
	Female Head		Male Head			Female Head		Male Head		
Coping strategy	Credit	No Credit	Credit	No Credit	All	Credit	No Credit	Credit	No Credit	All
Borrowing	0.3	0.5	1.4	1.5	3.8	0.8	1.3	2.5	1.4	6.0
Labour supply	1.1	6.2	4.1	13.1	24.6	1.8	3.2	5.7	12.8	23.5
Technology	0.3	0.9	0.7	2.4	4.4	0.2	2.5	0.4	5.4	8.4

Savings	2.4	4.7	14.4	17.1	38.6	1.8	3.9	16.0	16.9	38.5
Reduce consumption	2.2	6.4	5.6	14.3	28.5	1.5	1.4	10.1	10.6	23.5
	Pests					Livestock Epidemics				
	Female Head		Male Head			Female Head		Male Head		
	Credit	No Credit	Credit	No Credit	All	Credit	No Credit	Credit	No Credit	All
Borrowing	0.6	0.2	0.0	0.4	1.1	0.0	0.0	0.0	2.2	2.2
Labour supply	2.9	2.8	4.8	8.9	19.4	1.4	9.6	9.3	15.3	35.6
Technology	2.4	4.4	12.7	20.7	40.3	1.3	1.3	3.4	5.2	11.2
Savings	1.9	3.0	8.6	7.5	21.0	7.1	3.8	14.4	22.6	47.8
Reduce consumption	1.9	3.6	5.6	7.1	18.2	0.0	1.2	1.0	0.9	3.1
	2009/10									
	Drought					Floods				
	Female Head		Male Head			Female Head		Male Head		
	Credit	No Credit	Credit	No Credit	All	Credit	No Credit	Credit	No Credit	All
Borrowing	0.6	0.1	0.9	0.1	1.8	0.0	0.0	0.0	0.0	0.0
Labour supply	2.3	2.7	6.4	8.7	20.0	2.9	2.9	18.0	12.1	30.2
Technology	0.5	1.0	1.8	2.0	5.2	0.0	0.0	3.9	3.8	7.7
Savings	3.4	4.3	9.8	7.9	25.4	4.6	0.0	12.0	8.9	20.9
Reduce consumption	5.5	8.7	16.6	16.7	47.5	10.4	20.8	22.1	19.1	41.2
	Pests					Livestock Epidemics				
	Female Head		Male Head			Female Head		Male Head		
	Credit	No Credit	Credit	No Credit	All	Credit	No Credit	Credit	No Credit	All
Borrowing	0.0	0.0	4.5	0.0	4.5	0.0	0.0	0.0	0.0	0.0
Labour supply	3.4	1.6	3.6	1.2	9.8	0.0	0.0	6.8	3.0	9.9
Technology	1.5	6.0	5.2	8.5	21.2	0.0	0.0	3.5	3.2	6.7
Savings	1.5	1.2	8.1	16.2	26.9	8.3	0.0	34.3	31.4	74.1
Reduce consumption	7.6	4.0	9.3	16.6	37.6	0.0	5.0	4.4	0.0	9.4

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.4: Pooled MNL estimates for factors determining coping strategies against drought (Marginal effects)

	(1) FHHs				(2) MHHs			
Coping-drought	Borrowing	Labour supply	Technology	Use savings	Borrowing	Labour supply	Technology	Use savings
Age head	-0.000049	-0.00224	-1.63e-06	0.00017	2.27e-06*	-0.00095	-0.000118	-0.000073
	(0.00004)	(0.00155)	(0.00002)	(0.00209)	(0.000)	(0.00095)	(0.00012)	(0.00117)
Household size	-0.000108	-0.0168**	0.00016	0.03367**	1.8e-06	-0.00777	0.00102	-0.00054
	(0.00015)	(0.00561)	(0.00013)	(0.0118)	(0.00001)	(0.0061)	(0.00066)	(0.00573)
Urban					0.000091	0.10016*	0.004368	0.002292
					(0.00017)	(0.0624)	(0.01054)	(0.07363)
Access to credit	0.00152	0.1079*	-0.00058	-0.1899**	0.000031	-0.02631	-0.001788	0.059259
	(0.0023)	(0.06315)	(0.00091)	(0.06274)	(0.00008)	(0.03351)	(0.004)	(0.04687)
Region								
East	0.00182	-0.0471	-0.02249***	0.06548	-0.000052	-0.031194	0.028836*	-0.20977***
	(0.00339)	(0.05777)	(0.00657)	(0.13602)	(0.00008)	(0.05971)	(0.01748)	(0.06012)
West					0.000097	-0.16927***	-0.007262	-0.0846556
					(0.00012)	(0.04733)	(0.00466)	(0.08692)
Land tenure	-0.00093	0.13456**	-0.00032	-0.1792**	0.000056	0.077412*	-0.010674	0.16063**
	(0.00122)	(0.04744)	(0.00094)	(0.07964)	(0.00005)	(0.04208)	(0.00708)	(0.05344)
Off farm employ't head					0.000052	0.12615**	-0.004839	-0.03745
					(0.00007)	(0.03995)	(0.00364)	(0.03833)
Distance to market	0.000246*	0.0165***	-0.000099	0.00113	7.88e-06	0.00281	-0.000438	0.01345**
	(0.00015)	(0.00498)	(0.00009)	(0.01021)	(0.00001)	(0.00448)	(0.00067)	(0.00589)
Extension services	-0.00236**	0.2245	0.00227	-0.03429	0.000179	-0.13507***	-0.009116**	0.25738**
	(0.00078)	(0.23214)	(0.00305)	(0.13191)	(0.00019)	(0.03228)	(0.00347)	(0.0873)
Agro-ecologies								
WestNile	-0.00011	0.3152**	-0.00112*	0.0881	-0.00403***	0.163399**	-0.000305	-0.22794***
	(0.0012)	(0.12584)	(0.00065)	(0.14751)	(0.00122)	(0.0806)	(0.00673)	(0.05808)
Teso	-0.00433**	0.44025**	-0.00093**	0.00382				
	(0.00144)	(0.13993)	(0.00044)	(0.11959)				
Pastoral	-0.000061	0.11276	-0.00061	-0.03449	0.000247	0.123357	0.047858***	-0.068477
	(0.00131)	(0.07695)	(0.00089)	(0.119)	(0.00023)	(0.10446)	(0.01068)	(0.08928)
Montane	-0.00127**	-0.08125	0.00091	0.18478*	0.000134	-0.034961	-0.006567*	0.018014
	(0.0006)	(0.05105)	(0.0013)	(0.10323)	(0.00011)	(0.06124)	(0.00357)	(0.0859)
Banana/millet/cotton	-0.00375**	0.05666	-0.00358***	0.16006	-0.000583***	-0.077387	-0.006115*	0.067839

	(0.00127)	(0.10395)	(0.00098)	(0.20469)	(0.00015)	(0.05916)	(0.00356)	(0.09347)
Northern					-0.0001105**	-0.09522**	0.007757	-0.383866***
					(0.00005)	(0.03917)	(0.00809)	(0.03543)
Diagnostics								
No. of observations	346				1,094			
Population size	431,772				1,338,245			
Pseudo R^2	0.1640				0.1354			
Prob>chi^2	0.000				0.000			
Log likelihood	-457255.97				-1512397.80			
Base outcome	Reduce consumption				Reduce consumption			

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.5: Pooled MNL estimates for factors determining coping strategies against floods (Marginal effects)

	(1) FHHs		(2) MHHs		
Coping-floods	Labour supply	Use savings	Labour supply	Technology	Reduce consumption
Age head	0.00111	-0.00585	-0.001167	0.000857	-8.74e-06
	(0.00007)	(0.00546)	(0.00215)	(0.00071)	(0.00227)
Household size	0.000184	-0.02288			
	(0.0002)	(0.03923)			
Urban	0.0296	-0.07382	0.04667	0.07446	-0.16316
	(0.0525)	(0.21513)	(0.13048)	(0.10477)	(0.10969)
Region					
East	-0.00281	-0.25073**	0.01037	-0.03664	-0.21833**
	(0.0023)	(0.11599)	(0.2274)	(0.02302)	(0.1043)
West			-0.29347*	-0.02208	-0.19086
			(0.17742)	(0.04167)	(0.1367)
Off farm employ't head	0.000575	-0.01057	0.16701**	-0.03102	-0.07063
	(0.00156)	(0.20793)	(0.08213)	(0.02174)	(0.06911)
Distance to market	0.00636*	0.04531	-0.00682	0.00363	-0.01484*
	(0.00039)	(0.03613)	(0.00693)	(0.00384)	(0.00805)
Agro-ecologies					
Banana/millet/cotton	0.00633	-0.47633***	-0.09224	0.06516	0.34997
	(0.1135)	(0.10391)	(0.18653)	(0.10968)	(0.2267)
Banana/coffee	-0.5551***	0.1615	-0.2391***	0.00618	0.34937*
	(0.11999)	(0.21366)	(0.07451)	(0.03665)	(0.1824)
Northern	0.00353	0.00819	-0.05785	0.02523	0.16651
	(0.00725)	(0.48066)	(0.10607)	(0.05989)	(0.18003)
Teso			0.02544	0.35865	-0.11581
			(0.29045)	(0.31674)	(0.22063)
Montane	-0.00662**	-0.03423	0.02199	-0.06644	0.34795
	(0.0032)	(0.21134)	(0.25645)	(0.05345)	(0.23638)
Pastoral			-0.08545	-0.01054	0.297366
			(0.11761)	(0.03657)	(0.20397)
Diagnostics					
No. of observations	54		274		
Population size	51,324		223,039		
Pseudo R^2	0.4063		0.1473		
Prob>ch^2	0.000		0.000		
Log likelihood	-33074.16		-239891.76		
Base outcome	Reduce consumption		Use savings		

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.6: Pooled MNL estimates for factors determining coping strategies against crop pests (Marginal effects)

	(1) FHHs			(2) MHHS		
Coping-crop pests	Labour supply	Use savings	Reduce consumption	Labour supply	Use savings	Reduce consumption
Age head	-0.008397*	-0.004105	0.001082	0.00106	0.000828	0.00751**
	(0.00439)	(0.00305)	(0.00138)	(0.00205)	(0.00129)	(0.0035)
Household size	0.031526	0.002225	-0.014266*	-0.0286**	-0.01228	0.01008
	(0.02418)	(0.01996)	(0.00865)	(0.00999)	(0.01093)	(0.01328)
Access to credit				0.0805	0.19615	-0.08177
				(0.19835)	(0.20677)	(0.13903)
Urban	-0.10357	0.42717*	-0.02837	-0.06455	0.0375	0.40088**
	(0.10789)	(0.23672)	(0.04575)	(0.06092)	(0.09149)	(0.12768)
Availability of market	0.350954	-0.140987	0.14738*	-0.07044	-0.07375	0.44659***
	(0.25949)	(0.09841)	(0.0793)	(0.07245)	(0.05166)	(0.13813)
Distance to market	0.05419	-0.03092	0.0123**			
	(0.03639)	(0.02593)	(0.00594)			
Agro-ecologies						
Teso	-0.03465	-0.095437	-0.28252**	0.07656	-0.09567*	-0.0931
	(0.19308)	(0.11772)	(0.10651)	(0.11453)	(0.0573)	(0.18791)
Northern	-0.039501	0.11105	-0.04857**	0.07427	0.01019	-0.05688
	(0.1527)	(0.29313)	(0.0211)	(0.0845)	(0.07005)	(0.12978)
WestNile				0.05787	-0.284***	-0.0349
				(0.12089)	(0.04679)	(0.22572)
Banana/millet/cotton	0.8121***	-0.1961***	-0.04914*	0.00441	-0.02726	-0.23009*
	(0.08857)	(0.05743)	(0.02527)	(0.09194)	(0.07137)	(0.12146)
Banana/coffee	-0.5346**	0.34472**	0.03622	-0.1691**	0.005795	-0.15927
	(0.1734)	(0.15519)	(0.03614)	(0.07159)	(0.06315)	(0.12322)
Diagnostics						
No. of observations	68			211		
Population size	71,183			196,786		
*Pseudo R*2	0.2756			0.1590		
Prob>chi^2	0.000			0.000		
Log likelihood	-69970.09			-220849.44		
Base outcome	Technology			Technology		

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.7: Pooled MNL estimates for factors determining coping strategies against livestock epidemics (Marginal Effects)

	(1)		(2)	
Coping	FHHs		MHHs	
livestock epidemics	Labour supply	Reduce consumption	Labour supply	Technology
Age head	0.0102	1.46e-10	-0.000159	-0.000054
	(0.0087)	(0.000)	(0.00384)	(0.00005)
Household size	-0.0712*	-1.17e-06	-0.06406**	-1.47e-06
	(0.0365)	(0.000)	(0.02495)	(0.00047)
Urban	0.0952	0.00036	0.16746	-0.00192
	(0.2708)	(0.00068)	(0.21852)	(0.00151)
Region				
East			-0.03683	0.017167
			(0.14677)	(0.01381)
North	0.6706**	-0.00045	0.21494	0.009802
	(0.2249)	(0.00037)	(0.24955)	(0.01855)
West			0.37935	-0.008417**
			(0.45797)	(0.00372)
Land tenure system			-0.23766*	-0.0215
			(014506)	(0.01747)
Distance to market			0.02256	0.0002598
			(0.0176)	(0.00025)
Agro-ecologies				
Montane			-0.23397***	-0.009002**
			(0.06833)	(0.00435)
Teso	0.4981*	-0.000046	0.11887	0.006866
	(0.2889)	(0.00003)	(0.24934)	(0.01124)
Pastoral	-0.0574	-0.000233	-0.19251***	-000748**
	(0.2774)	(0.00017)	(0.05967)	(0.00333)
Diagnostics				
No. of observations	29		83	
Population size	25,936		89,438	
Pseudo R^2	0.4729		0.1748	
Prob>chi	0.000		0.000	
Log likelihood	-13669.44		-65203.63	
Base outcome	Use savings		Use savings	

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.8: Hausman-McFadden IIA test-Drought coping strategies

FHH					MHH				
Omitted	chi2	df	P>chi2	evidence	Omitted	chi2	df	P>chi2	evidence
Borrowing	0	3	1	for Ho	Borrowing	0	1	1	for Ho
Labour supply	0	6	1	for Ho	Labour supply	0	3	1	for Ho
Technology	0	3	1	for Ho	Technology	0	2	1	for Ho
Savings	0	6	1	for Ho	Savings	0	3	1	for Ho
Reduce cons.	45.049	33	0.079	for Ho	Reduce cons.	0	3	1	for Ho

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.9: Hausman-McFadden IIA test-Floods coping strategies

FHH					MHH				
Omitted	chi2	df	P>chi2	evidence	Omitted	chi2	df	P>chi2	evidence
Labour supply	0	3	1	for Ho	Labour supply	-0.475	24	1	for Ho
Technology				for Ho	Technology	-0.219	26	1	for Ho
Savings	0	4	1	for Ho	Savings	27.667	26	0.375	for Ho
Reduce cons.	0	4	1	for Ho	Reduce cons.	0.258	26	1	for Ho

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.10: Hausman-McFadden IIA test-Crop pests and diseases coping strategies

FHH					MHH				
Omitted	chi2	df	P>chi2	evidence	Omitted	chi2	df	P>chi2	evidence
Labour supply	0	1	1	for Ho	Labour supply	0	1	1	for Ho
Technology	0	3	1	for Ho	Technology	-85.277	21	1	for Ho
Savings	0	2	1	for Ho	Savings	0.733	22	1	for Ho
Reduce cons.	-0.001	2	1	for Ho	Reduce cons.	0	1	1	for Ho

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table B.11: Hausman-McFadden IIA test-Livestock epidemics coping strategies

FHH					MHH				
Omitted	chi2	df	P>chi2	evidence	Omitted	chi2	df	P>chi2	evidence
Labour supply	0	3	1	for Ho	Labour supply	0	3	1	for Ho
Savings	0	6	1	for Ho	Technology	-1.301	13	1	for Ho
Reduce cons.	-0.336	7	1	for Ho	Savings	0	2	1	for Ho

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Appendix C: Additional Chapter 5 results

Table C.1: Real consumption per adult equivalent at each decile

	2005/06			2009/10		
	Welfare_l	Welfare_m	Welfare_h	Welfare_l	Welfare_m	Welfare_h
National						
Decile 1	22244	21749	20949	22,776	22,240	21,482
Decile 2	28964	28301	27324	30,528	29,758	28,674
Decile 3	36240	35168	33855	37,938	36,912	35,640
Decile 4	43398	41994	40332	45,909	44,736	42,919
Decile 5	51726	50272	48337	53,969	52,835	50,692
Decile 6	63947	62008	59369	64,593	63,132	60,630
Decile 7	79940	77032	73489	80,028	77,487	74,375
Decile 8	104718	100755	96083	103,946	99,721	95,090
Decile 9	153625	146538	140024	150,876	147,030	140,723
Rural						
Decile 1	20,147	19,557	18,670	21,515	20,948	20,176
Decile 2	25,631	24,952	24,081	28,537	27,843	26,846
Decile 3	30,808	30,034	28,938	34,706	33,503	32,434
Decile 4	36,505	35,581	34,151	41,486	40,568	39,019
Decile 5	42,497	41,422	39,523	48,501	46,881	45,195
Decile 6	49,819	48,348	46,186	56,390	54,880	52,542
Decile 7	58,929	57,259	54,844	66,653	64,977	62,481
Decile 8	75,129	72,538	69,240	83,186	81,181	77,395
Decile 9	103,205	99,104	93,304	113,389	110,129	105,234
Urban						
Decile 1	40,666	39,687	37,893	41,152	40,302	38,202
Decile 2	56,129	54,427	52,534	60,583	58,759	56,383
Decile 3	70,054	68,034	66,338	76,542	73,731	70,232
Decile 4	85,390	81,894	76,316	94,351	91,296	87,077
Decile 5	98,801	95,624	92,314	111,323	106,929	101,902
Decile 6	118,909	113,963	107,046	129,925	126,345	119,600
Decile 7	144,869	138,444	131,863	168,906	163,485	152,488
Decile 8	191,681	182,858	173,476	220,398	212,866	202,921
Decile 9	269,040	254,759	243,610	301,251	284,316	267,182

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.2: Pooled OLS and 2SLS estimates of adaptation during droughts and welfare equations for poor and non-poor households

Log of welfare	(1) OLS Non-poor	(2) OLS Poor	(3) OLS Non-poor	(4) OLS Poor	(5) OLS Non-poor	(6) OLS Poor	(7) 2SLS Non-poor	(8) 2SLS Poor	(9) 2SLS Non-poor	(10) 2SLS Poor	(11) 2SLS Non-poor	(12) 2SLS Poor
Cope drought	-0.03**	-0.015*	-0.041**	0.000115	-0.201**	-0.042	-0.41**	0.068	-0.248**	0.296	-0.884	-1.113
	(0.010)	(0.0084)	(0.0123)	(0.0109)	(0.0955)	(0.0848)	(0.130)	(0.18)	(0.0957)	(0.240)	(1.170)	(2.908)
HH size			-0.0195**	-0.0110	-0.0525	-0.191**			-0.0179**	-0.027	-0.225	-0.335
			(0.00657)	(0.00942)	(0.107)	(0.0888)			(0.0074)	(0.021)	(0.325)	(0.378)
Age head			0.00135	-0.0034**	0.0134	-0.00854			0.00275	-0.006**	-0.0378	-0.067
			(0.0013)	(0.0012)	(0.0222)	(0.0129)			(0.0017)	(0.003)	(0.0872)	(0.164)
Gender of head			0.0537	-0.0550	-0.190	0.713			0.0297	-0.0097	-0.776	0.187
			(0.0441)	(0.0405)	(0.619)	(0.572)			(0.0524)	(0.077)	(1.225)	(1.492)
Education head												
Secondary			0.111*	0.0346	-0.343	1.326			0.116*	-0.198	-1.733	-3.220
			(0.0606)	(0.0666)	(0.799)	(0.922)			(0.0651)	(0.210)	(2.592)	(12.20)
Tertiary			0.491**	0.283***	-0.388	2.762			0.387*	0.373	-3.111	-6.421
			(0.177)	(0.0742)	(1.654)	(1.817)			(0.201)	(0.433)	(5.082)	(24.66)
Off farm employ't			0.0274	-0.00588	-0.314	-0.472			0.121*	0.0324	-3.295	-4.015
			(0.0440)	(0.0363)	(0.565)	(0.520)			(0.0645)	(0.083)	(5.210)	(9.693)
Land tenure			-0.0870*	-0.0199	-1.988**	-0.328			-0.145**	0.0304	-4.812	-5.602
			(0.0440)	(0.0568)	(0.675)	(0.787)			(0.0570)	(0.100)	(4.874)	(14.39)
Urban			0.272**	0.0835	-0.244	0.544			0.242*	-0.251	-0.872	1.370
			(0.101)	(0.141)	(1.857)	(1.407)			(0.133)	(0.347)	(2.426)	(2.565)
Agro-ecologies												
Banana/millet/cotton			-0.178**	0.166**	-0.189**	0.173**			-0.155*	0.327*	-0.158**	0.223
			(0.0616)	(0.0522)	(0.0557)	(0.0684)			(0.0855)	(0.196)	(0.0766)	(0.165)
Montane			-0.0105	0.0770	0.0501	0.0584			0.0137	0.191	0.0680	0.130
			(0.0499)	(0.0495)	(0.0521)	(0.0499)			(0.0606)	(0.167)	(0.0574)	(0.189)
Teso			0.117	0.114	0.248*	0.125			-0.113	0.481	0.291*	0.194
			(0.114)	(0.104)	(0.126)	(0.102)			(0.156)	(0.351)	(0.156)	(0.206)
Pastoral			-0.0365	-0.244**	0.170	-0.262**			-0.135	-0.0542	0.164*	-0.189
			(0.0770)	(0.0810)	(0.108)	(0.0896)			(0.108)	(0.196)	(0.0982)	(0.236)
WestNile			-0.203**	0.0400	0.0439	-0.00835			-0.405***	0.148	0.0297	-0.0748
			(0.0659)	(0.0406)	(0.128)	(0.0676)			(0.118)	(0.159)	(0.117)	(0.201)
Interaction terms												
Gender*copdr					0.0103	-0.0330					0.0359	-0.0104

					(0.0262)	(0.0244)					(0.0529)	(0.064)
Agro-ecology*copdr					-0.0021**	0.0004					-0.00158	0.0016
					(0.00093)	(0.0009)					(0.0013)	(0.0034
Urban*copdr					0.0222	-0.0190					0.0495	-0.046
					(0.0779)	(0.0612)					(0.103)	(0.092)
HH size*copdr					0.00134	0.00766**					0.00883	0.0138
					(0.00454)	(0.0038)					(0.0140)	(0.016)
Off farm* copdr					0.0148	0.0201					0.146	0.173
					(0.0245)	(0.0228)					(0.229)	(0.419)
Land tenure*copdr					0.0833**	0.0121					0.204	0.234
					(0.0284)	(0.0332)					(0.208)	(0.605)
Age HH*copdr					-0.000525	0.00022					0.00170	0.0027
					(0.000935)	(0.0006)					(0.0038)	(0.007)
Educ HH*copdr					0.0194	-0.0535					0.0803	0.139
					(0.0342)	(0.0386)					(0.113)	(0.517)
Un-weighted sample	1409	616	814	392	814	392	1409	616	814	392	814	392
Weighted sample	1,953,594	692,241	908,035	350,907	908,035	350,907	1,953,594	692,241	908,035	350,907	908,035	350,907
R^2	0.012	0.007	0.125	0.156	0.154	0.183	.	.	.	.	0.070	.
Prob<F	0.0018	0.0073	0.0001	0.0004	0.0000	0.0105	0.0025	0.7051	0.0039	0.0089	0.0000	0.0001

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.3: Pooled OLS and 2SLS estimates of impact of adaptation during floods on welfare equations for poor and non-poor households

Log of welfare	(1) OLS Non-poor	(2) OLS Poor	(3) OLS Non-poor	(4) OLS Poor	(5) OLS Non-poor	(6) OLS Poor	(7) 2SLS Non-poor	(8) 2SLS Poor	(9) 2SLS Non-poor	(10) 2SLS Poor	(11) 2SLS Non-poor	(12) 2SLS Poor
Cope floods	0.00204	0.0115	0.00248	0.028	0.124	-0.163	0.25**	0.027	-0.112	-0.0062	0.209	-1.303
	(0.015)	(0.015)	(0.014)	(0.021)	(0.104)	(0.208)	(0.10)	(0.26)	(0.09)	(0.349)	(0.144)	(3.371)
Gender head			0.0919	-0.0243	-0.285	-2.023**			0.074	-0.0445	0.131	-6.630
			(0.065)	(0.0776)	(0.916)	(0.912)			(0.08)	(0.226)	(1.063)	(13.51)
Age head			0.00067	-0.00224	0.0449*	-0.0284			0.0005	-0.00215	0.0617*	-0.160
			(0.002)	(0.0017)	(0.0272)	(0.0185)			(0.002)	(0.0016)	(0.0349)	(0.385)
Education head												
Secondary			0.0809		0.779				0.009*		1.335	
			(0.079)		(1.167)				(0.103)		(1.352)	
Tertiary			0.295*		1.670				0.164*		2.765	
			(0.178)		(2.312)				(0.247)		(2.634)	
HH size			-0.0178	-0.0128	0.0102	-0.0575			-0.018	-0.0129	0.0398	-0.140
			(0.0114)	(0.00945)	(0.167)	(0.124)			(0.014)	(0.0101)	(0.171)	(0.354)
Urban			0.285**	-0.409**	0.247**	-0.401**			0.329**	-0.359	0.252**	0.284
			(0.102)	(0.145)	(0.107)	(0.123)			(0.138)	(0.446)	(0.107)	(2.031)
Agro-ecologies												
WestNile			0.0306	0.0684	0.268**	0.249*			-0.0278	0.0452	0.260**	0.312
			(0.086)	(0.0729)	(0.121)	(0.152)			(0.127)	(0.233)	(0.119)	(0.213)
Pastoral			-0.161**	-0.209	0.0380	-0.0738			-0.023**	-0.230	0.0481	0.0313
			(0.070)	(0.143)	(0.0840)	(0.177)			(0.098)	(0.253)	(0.0858)	(0.337)
Teso			-0.00268	-0.0508	0.0796	-0.0728			-0.1487	-0.0974	0.0827	-0.0609
			(0.163)	(0.0717)	(0.151)	(0.0715)			(0.155)	(0.485)	(0.145)	(0.0856)
Banana/millet/cotton			-0.0522	0.0937	-0.121	-0.0476			-0.0899	0.0514	-0.130	-0.126
			(0.0846)	(0.0774)	(0.0868)	(0.0760)			(0.090)	(0.441)	(0.0844)	(0.240)
Land tenure				0.298*		-0.308				0.273		-8.464
				(0.156)		(2.395)				(0.381)		(24.13)
Interaction terms												
Gender*copflood					0.0162	0.0897**					-0.00226	0.301
					(0.0411)	(0.0419)					(0.0472)	(0.619)
Age HH*copflood					-0.00196*	0.00121					-0.00269*	0.00724
					(0.0012)	(0.0008)					(0.00153)	(0.018)
Educ HH*copflood					-0.0322						-0.0569	
					(0.0525)						(0.0601)	
HH size* copflood					-0.00115	0.00208					-0.00243	0.00549
					(0.0072)	(0.0054)					(0.0074)	(0.0152)
Agro-ecology*copflo					-0.003***	-0.0031*					-0.00298***	-0.0049

					(0.0008)	(0.0015)					(0.00083)	(0.0049)
Land tenure*copflood						0.0322						0.388
						(0.100)						(1.046)
Un-weighted sample	262	104	247	94	247	94	262	104	247	94	247	94
Weighted sample	222,046	80,254	193,742	74,258	193,742	74,258	222,046	80,254	193,742	74,258	193,742	74,258
R^2	0.0001	0.005	0.074	0.301	0.116	0.357	.	.	.	0.269	0.113	0.093
Prob>F	0.8915	0.4506	0.0017	0.0000	0.0013	0.0000	0.0177	0.9178	0.0056	0.0000	0.0017	0.0000

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.12: Pooled OLS and 2SLS estimates of impact of adaptation during crop pests on welfare equations for poor and non-poor households

Log of welfare	(1) OLS Non-poor	(2) OLS Poor	(3) OLS Non-poor	(4) OLS Poor	(5) OLS Non-poor	(6) OLS Poor	(7) 2SLS Non-poor	(8) 2SLS Poor	(9) 2SLS Non-poor	(10) 2SLS Poor	(11) 2SLS Non-poor	(12) 2SLS Poor
Cope pests	0.0030	0.010	-0.0455	0.0245	0.0635	0.353*	0.389	0.118	-0.132	0.304**	-0.0136	2.805
	(0.025)	(0.025)	(0.0305)	(0.0289)	(0.181)	(0.136)	(0.24)	(0.083)	(0.182)	(0.121)	(0.180)	(4.101)
Gender head			-0.0476	0.00519	-0.670	0.774			0.00153	0.0239	-0.241	6.341
			(0.119)	(0.0786)	(1.637)	(0.911)			(0.116)	(0.179)	(1.458)	(9.668)
Age head			-0.00139	-0.000455	0.0459	0.0431			0.000123	-0.0105	0.00101	0.574
			(0.003)	(0.00338)	(0.0445)	(0.0308)			(0.00335)	(0.00725)	(0.0524)	(0.886)
Educ HH/primary			0.112		0.246							
			(0.118)		(0.228)							
HH size			-0.00217	0.000197	0.102	0.256			-0.00737	-0.0483*	0.0454	2.174
			(0.011)	(0.0152)	(0.231)	(0.189)			(0.0122)	(0.0269)	(0.250)	(3.251)
Urban			0.415*	-0.440	0.417*	-0.576			0.440**	-0.999	0.446**	-2.677
			(0.200)	(0.293)	(0.203)	(0.348)			(0.191)	(0.675)	(0.173)	(3.525)
Farm size			0.00079	-0.0036***	0.159	-0.318			-0.0028	-0.00232**		0.684
			(0.0137)	(0.00067)	(0.244)	(0.344)			(0.0141)	(0.00094)		(1.665)
Land tenure			-0.269*	0.0789	-0.209	2.487			-0.209	0.306		9.294
			(0.132)	(0.169)	(1.554)	(1.297)			(0.139)	(0.243)		(12.41)
Agro-ecologies												
Teso			0.0958	0.166	0.179	-0.203				0.124		-0.354
			(0.158)	(0.107)	(0.204)	(0.220)				(0.203)		(0.756)
Banana/millet/cott			-0.0361	0.0936	0.118	-0.812			-0.0599	0.146	-0.135	-1.592
			(0.179)	(0.124)	(0.344)	(0.581)			(0.191)	(0.232)	(0.167)	(2.643)
Banana/coffee			0.0903	0.207	0.303	-0.997			0.138	0.109	0.221	-2.843

			(0.095)	(0.184)	(0.406)	(0.839)			(0.101)	(0.286)	(0.141)	(4.499)
WestNile				0.0470		0.722				-0.250		1.499
				(0.0996)		(0.376)				(0.347)		(2.179)
Montane				0.123	0.0914	-0.383				0.131		-0.551
				(0.114)	(0.225)	(0.394)				(0.209)		(1.505)
Interaction terms												
Gender*coppests					0.0291	-0.0294					0.0108	-0.261
					(0.0738)	(0.0401)					(0.0631)	(0.408)
Age HH*coppests					-0.00199	-0.00192					-0.000037	-0.0256
					(0.0019)	(0.0014)					(0.00225)	(0.0395)
Educ HH*coppests					0.00433							
					(0.0079)							
HH size*coppests					-0.00465	-0.0104					-0.00222	-0.0928
					(0.0103)	(0.0081)					(0.0110)	(0.140)
Farm size*coppests					-0.0070	0.0142						-0.0316
					(0.011)	(0.0156)						(0.076)
Land tenure*coppest					-0.0055	-0.109						-0.447
					(0.069)	(0.056)						(0.610)
Agrecology*coppes					0.0027	-0.0121					-0.000039	-0.0199
					(0.004)	(0.0083)					(0.0015)	(0.037)
Un-weighted sample	233	67	178	58	178	58	233	67	200	58	233	58
Weighted sample	243,202	58,730	165,425	52,930	165,425	52,930	243,202	58,730	213,927	52,930	243,202	52,930
R^2	0.000	0.004	0.193	0.263	0.215	0.402	.	.	0.091	.	0.149	.
Prob>F	0.9042	0.6963	0.0240	0.0000	0.0818	0.0000	0.1036	0.1622	0.0725	0.0000	0.2072	0.0000

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.13: Pooled OLS and 2SLS estimates of impact of adaptation during livestock epidemics on welfare equations for poor and non-poor households

Log of welfare	(1) OLS Non-poor	(2) OLS Poor	(3) OLS Non-poor	(4) OLS Poor	(5) OLS Non-poor	(6) OLS Poor	(7) 2SLS Non-poor	(8) 2SLS Poor	(9) 2SLS Non-poor	(10) 2SLS Poor	(11) 2SLS Non-poor	(12) 2SLS Poor
Cope livestock epidemic	0.0397	-0.0368	0.000902	-0.0451*	0.233	0.0646	0.685	-0.236	0.340	0.0586	2.728	1.003**
	(0.056)	(0.025)	(0.0410)	(0.0233)	(0.282)	(0.135)	(0.448)	(0.57)	(0.324)	(0.0929)	(2.707)	(0.447)
Gender head			-0.390**	0.0280	6.180*	-0.573			-0.335**	0.0295	11.98*	3.812
			(0.142)	(0.0851)	(3.102)	(1.060)			(0.143)	(0.108)	(7.292)	(3.382)
Age head			0.00086	0.00205	-0.000250	0.0392			0.00241	0.00184	0.312	0.308**
			(0.0027)	(0.0024)	(0.0459)	(0.0609)			(0.0051)	(0.0026)	(0.349)	(0.0934)
HH size			-0.0171	-0.024***	-0.111	0.139			-0.0511	-0.0325**	1.796	0.699
			(0.0203)	(0.0061)	(0.444)	(0.268)			(0.0394)	(0.0133)	(2.121)	(0.614)
Urban			0.313**	0.0409	3.469	.			0.423**	0.101	1.087	.
			(0.116)	(0.128)	(4.199)	.			(0.207)	(0.141)	(4.219)	.
Land tenure			-0.221*		-0.286				-0.261*		13.83	
			(0.126)		(2.344)				(0.131)		(15.61)	
Agro-ecologies												
WestNile			-0.0103	-0.165**	-0.131	-0.306**			0.0531	-0.181*	-0.0641	-0.267
			(0.201)	(0.0742)	(0.243)	(0.0864)			(0.296)	(0.0928)	(0.209)	(0.211)
Teso			-0.0474	-0.0247	-0.0737	-0.104			-0.238	-0.0382	0.0561	-0.351**
			(0.165)	(0.0698)	(0.164)	(0.0666)			(0.289)	(0.0991)	(0.265)	(0.131)
Banana/millet/cotto			0.283		0.344				0.413		0.219	
			(0.234)		(0.250)				(0.253)		(0.336)	
Montane			-0.0151		-0.0352				-0.0897		-0.0654	
			(0.238)		(0.236)				(0.334)		(0.325)	
Pastoral				-0.289*		-0.476**				-0.180		-0.488*
				(0.144)		(0.197)				(0.160)		(0.287)
Interaction terms												
Gender*coplivestoc					-0.292**	0.0249					-0.547*	-0.176
					(0.139)	(0.0461)					(0.321)	(0.151)
AgeHH*coplivesto					0.000064	-0.00163					-0.0138	-0.0138**
					(0.00206)	(0.00271)					(0.0155)	(0.0043)
HHsize*coplivestoc					0.00424	-0.00760					-0.0801	-0.0329
					(0.0196)	(0.0120)					(0.0936)	(0.0275)
Urban*coplivestock					-0.141	-0.00427					-0.0394	-0.0107

					(0.186)	(0.00585)					(0.186)	(0.0122)
Land tenure*coplep					0.00305						-0.620	
					(0.105)						(0.688)	
Agroecology*cople					0.000698	0.00179**					-0.00075	0.00351**
					(0.00147)	(0.00072)					(0.0021)	(0.00164)
Un-weighted sample	110	30	97	30	97	30	110	30	97	30	97	30
Weighted sample	120,527	21,737	105,970	21,737	105,970	21,737	120,527	21,737	105,970	21,737	105,970	21,737
R^2	0.006	0.058	0.207	0.412	0.242	0.562	.	.	.	0.031	.	.
Prob>F	0.4803	0.1601	0.0011	0.0004	0.0270	0.0000	0.1322	0.6817	0.0386	0.0113	0.0133	0.0063

Notes: Controlled for are strata-specific fixed effects and control years. In the parenthesis, are robust standard errors clustered at household level for all estimates to allow non-independence in errors at the household level. Standard errors in parentheses where, $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.001$

Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.6: 2SLS's Wooldridge robust score test –coping drought

Model type	Model (5.3) no controls		Model (5.4) with controls		Model (5.6) With interactions	
	F-value	P-value	F-value	P-value	F-value	P-value
All	21.0039	0.0000	3.2494	0.0717	1.2678	0.2604
Non-poor	20.1749	0.0000	3.9922	0.0461	2.4765	0.1160
Poor	0.2205	0.6389	5.9314	0.0154	10.8733	0.0011

Note: H_0: variables are exogenous
In all cases, if the test statistic is significant, the variable being tested must be treated as endogenous.
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.7: 2SLS's Wooldridge robust score test –coping floods

Model type	Model (5.3) no controls		Model (5.4) with controls		Model (5.6) With interactions	
	F-value	P-value	F-value	P-value	F-value	P-value
All	21.7089	0.0000	15.1035	0.0001	3.7730	0.0529
Non-poor	12.2584	0.0005	6.6608	0.0104	10.1826	0.0016
Poor	0.0032	0.9551	0.0089	0.9252	0.3920	0.5328

Note: H_0: variables are exogenous
In all cases, if the test statistic is significant, the variable being tested must be treated as endogenous.
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.8: 2SLS's Wooldridge robust score test –coping crop pests

Model type	Model (5.3) no controls		Model (5.4) with controls		Model (5.6) With interactions	
	F-value	P-value	F-value	P-value	F-value	P-value
All	5.0381	0.0255	0.8356	0.3616	0.0114	0.9149
Non-poor	4.3659	0.0378	0.4912	0.4842	0.8401	0.3603
Poor	1.8085	0.1833	13.6423	0.0005	8.4636	0.0052

Note: H_0: variables are exogenous
In all cases, if the test statistic is significant, the variable being tested must be treated as endogenous.
Source: Author's calculations based on the 2005/06 and 2009/10 panel

Table C.9: 2SLS's Wooldridge robust score test –coping livestock epidemics

Model type	Model (5.3) no controls		Model (5.4) with controls		Model (5.6) With interactions	
	F-value	P-value	F-value	P-value	F-value	P-value
All	11.5848	0.0009	0.7465	0.3893	1.4300	0.2341
Non-poor	6.1461	0.0147	2.6250	0.1085	2.3283	0.1303
Poor	0.3585	0.5540	1.0421	0.3158	12.8621	0.0012

Note: H_0: variables are exogenous
In all cases, if the test statistic is significant, the variable being tested must be treated as endogenous.
Source: Author's calculations based on the 2005/06 and 2009/10 panel