CODESRIA

Thesis

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FARMER STRATEGIES TOWARDS CLIMATE VARIABILITY AND CHANGE IN ZIMBABWE AND ZAMBIA

APRIL 2010

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Submitted in accordance with the requirements for the degree

PHILOSOPHIAE DOCTOR

In the

FACULTY OF ECONOMIC AND MANAGEMENT SCIENCES
CENTRE FOR DEVELOPMENT SUPPORT
UNIVERSITY OF THE FREE STATE
BLOEMFONTEIN

APRIL 2010

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DECLARATION

I declare that the dissertation hereby submitted by me for the qualification Philosophiae Doctor (Development Support) at the University of the Free State is my own independent work and has not previously been submitted by me for a qualification at/in another University/faculty. All sources referred to in this study have been duly acknowledged. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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ACKNOWLEDGEMENTS

First and foremost, I would like to thank Professor Pelser and Dr. Kundhlande, who have made this thesis a reality through their excellent academic mentorship as thesis promoters. I would also like to acknowledge the critical role played by Dr. Jemimah Njuki, who, in addition to providing intellectual support right from the proposal writing stage, introduced me to the broad IDRC funded research project, which has resulted in the outcome of this thesis. In the same breath, special mention goes to Professor Francis Mugabe who, as leader of the project, ensured that my university visits were possible and as comfortable as possible. Dr. Steve Twomlow also contributed to this work by providing academic guidance and making my stay at ICRISAT very comfortable. I would like to also acknowledge the smallholder farmers of Lupane and Lower Gweru (Zimbabwe) and Monze and Sinazongwe (Zambia). These farmers took their time off from their work and provided a home for me.

I would also like to express my gratitude to Dr. Emma Liwenga and Professor Yanda at the Institute of Resource Assessment (IRA), University of Dar es Salaam, for providing intellectual support in the final stages of this thesis. Acknowledgement also goes to Dr Majule at the same institute, who took time to read Chapter Six of this thesis. To them I say *Asanteni sana!* My stay at this institute enabled me to go through the write up of my thesis in a smooth way. I further acknowledge the contribution from Angeline Chamunorwa Mujeyi and Eness Paidamoyo Mutsvangwa in the data analysis for this thesis. Special mention also goes to Durton Nanja for field work assistance. Thank you, Durton, for taking me to the farmers on your motorbike and for talking to these farmers in Tonga on my behalf. I know you are almost there and will soon make it for your PhD. Special mention also goes to Mr Chesterfield Vengesayi and Francia for the language and technical editing of this thesis.

To my husband, Vincent, I would like to thank you so much for being so patient in my long absences from home for the entire duration of the study and for looking after our daughter, Tanatswa. Vincent, thank you so much for also commenting on my work and providing insights and believing in me. Tanatswa, I am sorry for denying you your mother's love at such a tender age. I would also like to thank the following people: the Mungures for providing moral support to my family during this time, Blessing for being there for my daughter when she was not in school, Memory Padzarondora for checking on my kid at school, my parents for being an inspiration, my only and dear sister, Zororo, for being there for me and providing moral support, Bella Nyamkure for her moral support, Patience Mutopo and Plan Shenjere for providing both intellectual and moral support during our shared road as PhD students and my aunts Grace for her endless encouragement and Doreen for her support during my university visits and also for providing inspiration and believing in me. Rita Kyomugisha, thank you for making my stay in Dar es Salaam more comfortable than it would otherwise have been without your friendship. Many more people contributed to this work in one way or another. However, I cannot mention them all by name but I remain grateful for all their efforts.

I am grateful for funding from the International Development Research Centre (IDRC) through Climate Change Adaptation in Africa (CCAA) and also for additional funding from START through the African Climate Change Fellowship Programme (ACCFP), in which part of activities for this study was funded. Gratitude is also expressed to CODESRIA for the Small Grants Programme which also funded this work. I also thank the following organisations in which the project was hosted and researchers from these organisations who contributed as collaborators and researchers in the field work: researchers from Zambia Agricultural Research Institute (ZARI), Zambia Agro-Met and researchers and students from Midlands State University (MSU) Zimbabwe, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Zimbabwe and International Centre for Tropical Agriculture (CIAT), Zimbabwe. The views expressed in the thesis are those of the author and are not necessarily those of the funding agencies.

I dedicate this thesis to my husband Vincent Itai Tanyanyiwa and our daughter Tanatswa.

CP MUBAYA

ABSTRACT

There is wide scientific consensus that concentrations of greenhouse gases in the atmosphere are increasing due to human activities, causing global climate change. Climate change exerts significant pressure on the agricultural sector and economic development of Africa. Despite a growing number of country-level case studies, knowledge gaps continue to exist at the level of impact analysis. In addition, while adaptation and coping with climate variability and change have become key themes in current global climate discussions and policy initiatives, literature on adaptation in Zimbabwe and Zambia appears to be still limited.

In this regard, this study addressed the following objectives:

- To investigate farmer perceptions of threats from climate variability and change and how these may differ across countries;
- To identify and analyse the impacts of climatic variability and change on farmer households in the two countries; and,
- To identify coping and adaptation strategies to climate variability and change employed by farmers and investigate factors influencing choice of adaptation/ coping strategies across the study districts

Methods used to collect data for this study are both qualitative and quantitative methods. The specific method used in the Quantitative approach is the survey. Qualitative methods used include Participatory Rural Appraisal (PRA), specifically, resource mapping, historical trend lines, seasonal and daily activity calendars and matrix scoring and ranking. FGDs and in-depth case studies were also used.

Conclusions drawn from the findings of the study are listed below:

- While farmers report changes in local climatic conditions consistent with climate change, there is a problem in assigning contribution of climate change and other factors to observed negative impacts on the agricultural and socio-economic system
- While there are multiple stressors that confront farmers, climate variability and change remain the most critical and exacerbate livelihood insecurity for those farmers with higher levels of vulnerability to these stressors
- There are variations in manifestations of direct and structural impacts from climate variability and change as a result of differences in types of farming systems and general economic and political contexts
- Apart from its overwhelmingly negative effects, climate variability might also have a positive impact and localised benefits in the context of structural changes in communities–social organization and economic activities-under certain circumstances

- Significant responses to climate variability and change involve organizing agriculture and related practices, than switching to off farm initiatives
- While farmers' selection of coping and adaptation strategies to climate variability and change and the associated outcomes may be intrinsic, this selection tends to be overwhelmingly shaped by diverse factors such as demography, access to information and assets and vulnerability levels

Following the above conclusions, the study recommended that there is need to:

- Strengthen the capacity of farmers and institutions for identifying and assessing climate changes through programmes to educate farmers and other relevant stakeholders on climate change and variability and their potential impacts on farmers' livelihoods
- Make a transition *from* designing policies that target climate change issues as a distinct entity *to* policies that address climate change issues as an integral component of multiple stressors that confront farmers
- Design appropriate policies that buttress farming systems against climate variability and change through taking into account variations in these farming systems and other relevant factors
- Make a transition *from* conceptualisation of climate change impacts in the policy framework as being inherently negative, *to* research and policy making with an open-minded lens that dissects climate change and variability impacts in order to enhance alternative livelihoods for farmers
- Provide support for appropriate agricultural innovations and development of new livelihood activities emerging as farmers respond to climate variability and change
- Integrate sectors through interventions that target agricultural extension, meteorology, academic research and other developmental activities through civil society organisations

Key words: Climate change, Climate variability, Farmers, Perceptions, Vulnerability, Impacts, Coping, Adaptation, Zimbabwe, Zambia

Abstrak

Daar bestaan algemene wetenskaplike konsensus dat die konsentrasies kweekhuisgasse in die atmosfeer aan die toeneem is as gevolg van menslike aktiwiteite, met die gevolglike globale klimaatsverandering. Klimaatsverandering oefen betekenisvolle druk uit op die landbousektor en die ekonomiese ontwikkeling van Afrika. Ten spyte van 'n toenemende aantal gevallestudies waarby verskillende lande betrek word, bly kennisgapings voortbestaan op die vlak van impakanalise. Verder, alhoewel aanpassing by klimaatsveranderlikheid en -verandering en die hantering daarvan sleutelkwessies in huidige globale besprekings en beleidsinisiatiewe betreffende klimaat geraak het, kom dit voor asof literatuur oor aanpassing in Zimbabwe en Zambië steeds beperk is.

Hierdie studie het die volgende oogmerke in hierdie verband aangespreek:

- Om boere se persepsies rakende dreigemente van klimaatveranderlikheid en klimaatsverandering te ondersoek, asook hoe dit van land tot land mag verskil;
- Om die impak van klimaatsveranderlikheid en -verandering op boerdery-huishoudings in die twee lande te identifiseer en te analiseer; en
- Om hantering- en aanpassingstrategieë te identifiseer om klimaatsveranderlikheid en -verandering wat deur boere toegepas word te identifiseer, asook faktore te ondersoek wat die keuse van aanpassing/hanteringstrategieë in die distrikte wat bestudeer is, beïnvloed.

Kwalitatiewe sowel as kwantitatiewe metodes is gebruik om data vir hierdie studie in te samel. Die spesifieke metode wat in die Kwantitatiewe benadering gebruik is, is die gebruik van opnames. Kwalitatiewe metodes wat gebruik is, sluit Deelnemende Landelike Skatting (*Participatory Rural Appraisal* – PRA) in, spesifiek hulpbronkartering, historiese tendenslyne, seisoenale en daaglikse aktiwiteitskalenders en matriksoptekening en rangskikking. FGB's en deeglike gevallestudies is ook gebruik.

Gevolgtrekkings wat uit die bevindings van die studie gemaak is, word hieronder gelys:

- Terwyl boere veranderings in plaaslike klimaatstoestande in ooreenstemming met klimaatsverandering rapporteer, bestaan daar 'n probleem in die bepaling van die bydrae van klimaatsverandering en ander faktore tot waargenome negatiewe soorte impak op die landbou- en sosio-ekonomiese stelsel.
- Terwyl boere voor veelvuldige stressors te staan kom, bly klimaats-veranderlikheid en -verandering die mees kritieke stressors, en vererger dit die bestaansonsekerheid van daardie boere met hoër vlakke van kwesbaarheid as gevolg van hierdie stressors.
- Daar bestaan variasies in die manifestering van die direkte en strukturele impak van klimaatsveranderlikheid en -verandering as gevolg van verskille in die tipes boerderysisteme en algemene ekonomiese en politieke kontekste.

- Afgesien van die oorweldigende negatiewe effek daarvan, kan klimaatsveranderlikheid onder sekere omstandighede ook 'n positiewe uitwerking hê en gelokaliseerde voordele inhou in die konteks van strukturele veranderings in gemeenskappe, byvoorbeeld sosiale organisasie en ekonomiese aktiwiteite.
- Betekenisvolle reaksies op klimaatsveranderlikheid en -verandering behels die organisering van landbou- en verwante praktyke, eerder as om landbou-inisiatiewe na nie-landbougerigte inisiatiewe oor te skakel.
- Terwyl boere se keuse van hantering- en aanpassingstrategieë met betrekking tot klimaatsveranderlikheid en -verandering, asook die verwante uitkomste intrinsiek mag wees, neig hierdie keuse om oorweldigend gevorm te word deur diverse faktore soos demografie, toegang tot inligting en bates, en kwesbaarheidsvlakke.

Voortspruitend uit bogenoemde gevolgtrekkings beveel die studie aan dat daar 'n behoefte bestaan aan:

- Die uitbouing van die kapasiteit van boere en instansies om klimaatsverandering te identifiseer en te assesseer met behulp van programme om boere en ander relevante rolspelers op te voed oor klimaatsverandering en klimaats-veranderlikheid en die potensiële impak daarvan op boere se voortbestaan.
- 'n Oorgang *vanaf* ontwerpbeleid wat kwessies rakende klimaatsverandering teiken as 'n kenmerkende entiteit *na* beleid wat kwessies rondom klimaatsverandering aanspreek as 'n integrale komponent van die talle stressors waarvoor boere te staan kom.
- Die ontwerp van toepaslike beleid wat boerderysisteme beveilig teen klimaatsveranderlikheid en -verandering deur wisselings in hierdie boerderysisteme en ander relevante faktore in berekening te bring.
- 'n Oorgang *vanaf* die konseptualisering van die impak van klimaatsverandering in die beleidsraamwerk as synde inherent negatief, *na* navorsing en beleidmaking met 'n onbevange lens wat die impak van klimaatsverandering en klimaats-veranderlikheid ontleed ten einde alternatiewe bestaansmoontlikhede vir boere te verhoog.
- Ondersteuning vir toepaslike landbou-innovering en die ontwikkeling van nuwe ontluikende bestaansaktiwiteite namate boere op klimaatsveranderlikheid en klimaatsverandering reageer.
- Die integrasie van sektore deur intervensies wat meteorologie, uitbreiding op landbougebied, akademiese navorsing en ander ontwikkelingsaktiwiteite met behulp van burgerlike samelewingsaktiwiteite teiken.

Sleutelwoorde: Klimaatsverandering, Klimaatsveranderlikheid, Boere, Persepsies, Kwesbaarheid, Impak, Hanteringstrategieë, Aanpassing, Zimbabwe, Zambië

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ACRONYMS

AIACC - Assessments of Impacts and Adaptations of Climate Change
ACT - Action by Churches Together
BUHI - Botswana Upper High Influence
CABS - Congo Air Boundary
CAN - Climate Action Network
CAP - Common Agricultural Policy
CAR - Central African Republic
CCIR-NYC - Climate Change Information Resources- New York Metropolitan Region
CDC - Centre for Diseases Control
CF -Conservation Farming
CH4 - Methane
CO2 - Carbon dioxide
CRED - Centre for Research on Epidemiology of Disasters
CRS -Catholic Relief Services
CRU -Climate Research Unit
DDMC - District Disaster Management Committee
DFID - Department for International Development
DHMB -District Health Management Board
DMMU-OVP (Zambia) Disaster Management and Mitigation Unit (of Zambia)
DMSP - Defence Meteorological Satellite Program
DRC - Democratic Republic of Congo
DTI - Department of Trade and Industry
DWD - Directorate of Water Development
ECF - East Coast fever
EEA - European Environment Agency
ENSO - El Niño Southern Oscillation
EU - European Union
FAO - Food and Agriculture Organisation
FGDs - Focus Group Discussions
FMD - Foot-and mouth disease
FOSENET - Food Security Network
Gt - Gigatons
GCM - Global Circulation Model
GDP - Gross Domestic Product
GEC - Global Environmental Change
GHG - Greenhouse Gases
GMB - Grain Marketing Board

GoZ - Government of Zimbabwe
IDRC-International Development Research Centre
IFC- International Finance Corporation
IISD -International Institute for Sustainable Development
IOC - Indian Ocean Commission
IPCC - Intergovernmental Panel for Climate Change
ISDR - International Strategy for Disaster Reduction
ITCZ - International Tropical Convergence Zone
MARA/ARMA - Mapping Malaria Risk in Africa project
MDGs - Millennium Development Goals
NAPA - National Adaptation Plan of Action
NAST - National Assessment Synthesis Team
NEAP - National Environment Action Plan
NEMA - National Environment Management Authority
NGO - Non-Governmental Organisations
NOAA - National Oceanic and Atmospheric Administration
NR - Natural Region
N2O - Nitrous oxide
NSF - National Science Foundation
O3 - Tropospheric ozone
OECD - Organisation for Economic Co-operation and Development
ORAP - Organization of Rural Association for Progress
PRA - Participatory Rural Appraisal
RHC - Rural health centres
RVAC - Regional Vulnerability Assessment Committee
RVF - Rift Valley Fever
SADC - Southern African Development Community
SRES - Special Report on Emissions Scenarios
TAR - Third Assessment Report
UK - United Kingdom
UN -United Nations
UNCCD - United Nations Convention on Climate and Desertification
UNDP - United Nations Development Programme
UNEP - United Nations Environment Programme
UNESCO - United Nations Education Scientific and Cultural Organisation
UNFCCC - United Nations Framework for the Convention of Climate Change
UNFPA - United Nations Population Fund
UNSO/GoU - United Nations Sudano-Sahelian office/Government of Uganda
USA - United States of America
USAID - United States Agency for International Development

USD - United States Dollar

VAC - Vulnerability Assessment Committees

WBGU - German Advisory Council on Global Change

WFP - The World Food Programme

WHO - World Health Organization

WMO - World Meteorological Organisation

WRI - World Resources Institute

ZimVAC - Zimbabwe Vulnerability Assessment Committee

ZINC - Zimbabwe Initial National Communication

ZRCS - Zambia Red Cross Society

CHAPTER 1: THE RESEARCH CONTEXT

1.1 BACKGROUND AND INTRODUCTION

There is wide scientific consensus that concentrations of greenhouse gases in the atmosphere are increasing due to human activities, causing global climate change (Mendelsohn & Dinah, 2005 and Rosenzweig & Solecki, 2009) and that the inevitable global warming will have major impacts on the climate worldwide (Intergovernmental Panel for Climate Change [IPCC] 2007). According to Rosenzweig and Solecki (2009), although the climate system includes a great deal of natural variability, climate fluctuations have always been part of the Earth's 4.6 billion year history. However, changes in concentrations of greenhouse gases in the atmosphere over the past century are of an unprecedented rate and magnitude. In the same respect, the probability that climate change is already occurring and that past emissions of greenhouse gases have already committed the globe to further warming of around 0.1°C per decade for several decades is high (Mendelsohn & Dinah, 2005 and Solomon *et al.*, 2007). The IPCC and scientists who have worked over several years have provided evidence of global warming and have reached the conclusion that the source is mainly anthropogenic (United Nations Development Programme [UNDP] 2004). Global warming has largely been attributed to a build-up of Greenhouse Gases (GHG) in the Earth's atmosphere, largely resulting from the burning of fossil fuels by the industrialised countries since the beginning of the industrial era. The IPCC Fourth Report (2007) dispels any uncertainty about climate change and gives detailed projections for the 21st century which show that global warming will continue and accelerate.

Climate change is cited as a complex and interdependent environmental challenge facing the world today (Clark *et al.*, 2002). Expected repercussions of climate change are twofold: bio-physical and socio-economic, in which case the latter are central to this study. On the one hand, bio-physical impacts include rising sea waters, more frequent and intense storms, the extinction of species, worsening droughts and crop failure. In addition, changes in cloud cover and precipitation, melting of polar ice caps and glaciers and reduced snow cover are among other bio-physical impacts that have been observed (Mendelsohn & Dinah, 2005; UNDP, 2004 and United Nations Framework for the Convention of Climate Change [UNFCCC] 2007). On the other hand, socio-economic impacts are characterised by multiple linkages with bio-physical impacts such as environmental degradation. For instance, food security and poverty reduction have been considered to be linked to environmental degradation (Clark *et al.*, 2002 and Koch *et al.*, 2006). Such linkages have emanated from expectations that climate change will affect food and water resources that are critical for livelihoods and survival across developing countries (and Africa in particular) where much of the populations rely on local supply systems that are sensitive to climate variation (Nhemachena & Hassan, 2008). Projected scenarios estimate a 5-7% potential increase in malaria distribution by 2100 (Tanser *et al.*, 2003). The social and economic costs of malaria are huge and include considerable costs to individuals and households as well as high costs at community and national levels (Holding & Snow, 2001; Malaney *et al.*, 2004 and Utzinger *et al.*, 2001).

In the same respect, there are linkages between agriculture and socio-economic impacts from climate change. The area suitable for agriculture and the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This can further adversely affect food security and exacerbate malnutrition in the affected areas. In some countries, yields from rain-fed agriculture can be reduced by up to 50% by 2020 (IPCC, 200b). Moreover, climate models show that 600 000 square kilometres classified as moderately water constrained will experience severe water limitations across the globe. By 2020 between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change (IPCC, 2007b). Although impacts will differ in different parts of the world, it is expected that these repercussions will affect every nation on earth (UNDP, 2004).

It is estimated that with an average global temperature increase of 3-4°C per decade, the additional costs of adapting infrastructure and buildings is likely to range from 1–10% of the total cost invested in construction in Organisation for Economic Co-operation and Development[1] (OECD) countries. In addition, while the cost of making new buildings and infrastructure more adaptable to climate change in these countries is likely to range from $15-150 billion each year (0.05-0.5% of Gross Domestic Product [GDP] in additional costs); the impact on the global economy will possibly lead to a decline of 3% in output (Stern, 2007). As estimated by the IPCC, likely economic impacts on OECD countries in Europe in 2010 will range from 0.13 to 1.5% of GDP. The cost of stabilising greenhouse gases at a manageable level will cost around 1% of GDP (IPCC, 2001 and Stern, 2007).

Developed countries have released the greater proportion of greenhouse gases and are also best positioned financially to reduce those emissions (Mendelsohn & Dinah, 2005 and Sokona & Denton, 2001). However, extreme climatic events such as hurricanes, prolonged droughts and floods are considered to have dramatic impacts on the unfortunate people in these countries, but more so, on the poor as even small climatic changes can present an extreme burden by bringing hunger, disease and even death. For instance, projections suggest that the number of people at risk from coastal flooding will increase from 1 million in 1990 to 70 million in 2080 (IPCC, 2001; IPCC, 2007b; Mendelsohn & Dinah, 2005 and

[1] This is a Paris-based international economic organisation of 30 countries. Most OECD members are high income economies with a high Human Development Index (HDI) and are regarded as developed countries

Sokona & Denton, 2001). Impacts of global warming such as disruptions in food and water systems will adversely affect development and livelihoods and will most likely add to the already existing challenges for poverty eradication. This is likely to impact on the social as well as cultural and economic development of poor rural communities (e.g. Howden, *et al.* 2007 and Mortimer & Manvel, 2006) and agricultural productivity, particularly in sub-Saharan Africa (Mendelsohn *et al.*, 2000a & 2000b and Twomlow *et al.*, 2008). In Africa as a whole, food demand exceeded domestic production by 50% in the drought-prone mid-1980s and more than 30% in the mid- 1990s (World Resources Institute [WRI] 1998). Africa is among the regions with the lowest food security and the lowest ability to adapt to future changes. In Southern Africa, 40% of the population is undernourished (Twomlow *et al.*, 2008).

1.1.1 CLIMATE CHANGE AND AGRICULTURE

Climate variability directly affects agricultural production since agriculture is inherently sensitive to climatic conditions and is one of the most vulnerable sectors to the risks and impacts of global climate change. Any significant change in climate at a global scale should impact on agriculture at the local scale (Parry *et al.*, 1999 and Rosenzweig & Hillel, 1995). For instance, in the United States of America (USA), climate change is predicted to lead to a reduction in the aggregate rain-fed cropped acreage, a reduction in yield and increases in crop water demand (Adams *et al.*, 1990 and Parry *et al.*, 2004). Although there are later studies showing that model simulations suggest that the net effects of the climatic scenarios studied on the agricultural segment of the US economy over the 21st century are generally positive (National Assessment Synthesis Team [NAST] 2000), there are indications that tick-borne diseases may increase, posing new challenges (Lindgren *et al.*, 2000).

Therefore, concern for future agricultural impacts on important natural resources, especially land and water, seems to be justified. In addition, a recent report by the Climate Action Network (CAN) of Australia projects that climate change is likely to reduce rainfall in the rangelands, which could lead to a 15% drop in grass productivity. This, in turn, is likely to lead to reductions in the average weight of cattle by 12%, significantly reducing beef supply. Under such conditions, dairy cows are projected to produce 30% less milk and new pests are likely to spread in fruit-growing areas (Schwartz & Randall, 2003). Similarly, adverse climatic events are now a more acute source of vulnerability in the Mexican agriculture than before, since multiple socio-economic stressors are now in action. The relationship between droughts and El Nino events in Mexico has been documented and El Nino events have impacted negatively on rainfed maize production in the last 40 years (Conde *et al.*, 2006). Rainfed maize production is the most important agricultural activity for the majority of subsistence farmers in Mexico (Conde *et al.*, 2006).

Climate change associated with increasing levels of carbon dioxide is likely to affect developed and developing countries differentially, with major vulnerabilities occurring in low-latitude regions (e.g., Darwin & Kennedy, 2000 and Reilly *et al.,* 2001). Moreover, climate change is likely to increase the disparities in cereal yields between developed and developing countries in a more significant way than has been found in previous studies (Parry *et al.,* 2004). In this respect, climate will exert significant pressure on the economic development of Africa, particularly for the agricultural and water-resources sectors, at regional, local and household scales (Boko *et al.,* 2007). The agricultural sector is a critical mainstay of local livelihoods and national GDP in some countries in Africa (Devereux & Maxwell, 2001 and Mendelsohn *et al.*, 2000a & 2000b) and climate change could exacerbate social and economic instability for countries that rely on agriculture. Different features of the climatic system changes that are considered to affect farming include increase in temperature and its geographic distribution, humidity, wind patterns and the changes likely to occur in precipitation patterns as agriculture of any form is influenced by availability of water. The demand for water for agriculture increases in a warmer climate and when there is a decrease in precipitation (Rosenzweig & Hillel 1995 and Unganai 1996). For example Kenya, Tanzania and Mozambique experience warmer climates and are challenged by persistent droughts. Accustomed to dry conditions, these countries are the least influenced by changing weather conditions, but their food supply is challenged as major grain producing regions suffer (Schwartz & Randall, 2003).

The implication herein is that there is, therefore, need for farmers in such cases to respond by growing crops that are more drought tolerant than the ones that they would normally grow in normal seasons. Climate changes also affect crops and livestock as pests and disease infestation is exacerbated in warmer climates. Additional use of chemicals for both the soil and livestock may further impact water and air quality (Rosenzweig & Hillel, 1995 and Sutton, 2007). These challenges are usually aggravated by periods of prolonged droughts and/or floods and are often particularly severe during El Nino events (Boko *et al.,* 2007 and Mendelsohn *et al.*, 2000a).

While the preceding paragraphs elaborate on the impacts of climate change on agriculture, it is important to note that climate change amplifies already existing risks for farmers. This is the case as there are non-climatic risk factors such as economic instability, trade liberalisation, conflicts and poor governance that may also be faced by farmers. Other factors are impacts of diseases such as malaria and HIV and AIDS and lack of and limited access to climate and agricultural information (Gandure, 2005; Gandure & Marongwe, 2006 and Nyong & Niang-Diop, 2006). Africa is also characterised by institutional and legal frameworks that are, in some cases, insufficient to deal with environmental degradation and disaster risks (Beg *et al.*, 2002; Sokona & Denton, 2001). However, vulnerability levels are heightened when there are droughts and floods, among other climate risk factors (Gandure & Marongwe, 2006). It is, therefore, important to understand that non-climate risk factors may compound the situation for farmers already faced with climate variability and change.

In addition, it is important to note that not all impacts of climate change are negative. For instance, in the USA, changes in precipitation and temperatures under simulated doubled-Carbon dioxide (CO_2) conditions favour irrigated crop production. There have been recorded increases in acreage in irrigated crops in the Northern plain and in the Delta (Adams *et al.,* 1990). In North America, South East America, and Australia, the effects of CO_2 on the crops partially compensate for the stress that is imposed on the crops by certain climatic conditions and result in small yield increases (Parry *et al.,* 2004). Under some climate modelling scenarios, crop yields increase as a result of regional increases in precipitation that compensate for the moderate temperature increases, and as a result of the direct effects of the high concentration of CO_2. In contrast, crop yields dramatically decrease in developing countries as a result of regional decreases in precipitation and large temperature increases in the modelled climate scenarios (Adams *et al.,* 1990). Similarly, due to a combination of increased temperature and rainfall changes, certain parts of Africa, such as Ethiopia in the east and Mozambique in the south, are likely to experience extended growing seasons, a fact which will benefit these areas. Mild climate scenarios project further benefits across African croplands for irrigated and, especially, dryland farms (Thornton *et al.,* 2006). However, the same favourable scenarios may impact negatively on populated regions of the Mediterranean and some parts of Central, Western and Southern Africa due (Boko *et al.,* 2007). The notion that there may be positive impacts and advantages emanating from climate change is important for this study in order to understand how climate change may benefit some sections of society (e.g. small-scale farmers) while it affects others negatively.

1.1.2 CLIMATE CHANGE ADAPTATION

The increasing realization that future climate change may pose a serious threat to society raises the question of how to adapt to these changes- a question which is now receiving attention from researchers, governments and organisations (Burton *et al.*, 2002; Hertin *et al.*, 2003; Smit & Pilifosova, 2001; Smit *et al.*, 1999 and Subak, 2000). The increasing attention to the issue of adaptation provides a context for this study to understand how target farmers respond to the vagaries of climate change as there is little research that has been documented on climate change adaptation in Africa, and more particularly in countries such as Zambia[2] and Zimbabwe. Adaptation to climate change is, of course, not a new phenomenon. Throughout the history of society, communities have adapted to climate variability through different ways such as altering settlements and agricultural patterns. However, this adaptation has mainly been in reaction to natural climate effects. The recent

[2] A case study of Zambia and Zimbabwe has been selected for this study. See Chapter Four for a detailed description of reasons for selection and selection procedures

phenomenon of human induced climate change, therefore, poses a new dimension to this age old challenge (Burton *et al.*, 2006). The record further shows that there are limits to adaptation (Burton *et al.*, 2006).

Adaptation and coping with climate variability and change have become key themes in current global climate discussions and policy initiatives (Downing & Patwardhan, 2003; Reid & Vogel, 2006 and United Nations Environment Programme [UNEP] 1998, 2001). The terms have often been used with different interpretations and for different purposes (Downing, 2002). In fact, there appears to be a dearth of literature on coping as distinct from adaptation as literature on adaptation predominantly bunches the two concepts and uses them interchangeably. In addition, while the overall record of adaptation to climate change and variability in the past 200 or so years has been successful overall, there is evidence of insufficient investments in adaptation opportunities, especially in relation to extreme events (Burton, 2004; Burton & May, 2004 and Hallegatte *et al.*, 2007). From literature, we can learn how the rural poor currently cope with the vagaries of climate and how these can be used to help them adapt their current production systems to the future threats of further climate change.

It is important at this point to note that adaptation is not always in response to a single stressor such as drought risk, but rather the outcome of a process of considering simultaneously a wide variety of stressors—including, but not limited to climatic factors (Reid & Vogel, 2006). In order to understand what adaptation options are needed and possible, it is important to identify the climatic variables to which the adaptations relate and to consider the role of non-climatic factors that influence the sensitivity of rural livelihoods to climate change (Wehbe *et al.*, 2006).

1.2 THE PROBLEM STATEMENT

It is predicted that climate variability will increase, characterised by heightened frequency and intensity of extreme weather conditions in Africa (Clay *et al.,* 2003 and Nhemachena & Hassan, 2008). The implications for Southern Africa are that the region will probably get drier generally and will therefore experience more extreme weather conditions, particularly droughts and floods, although there is the probability of variations within the region with some countries experiencing wetter than average climate. This is compounded by the fact that the climate of Southern Africa is highly variable and unpredictable and the region is prone to extreme weather conditions, including droughts and floods (Department for International Development [DFID] 2004; Kinuthia, 1997). Essentially, Southern Africa is a region characterised by high spatial and temporal climate variability. In the predominantly semi-arid Southern African region, there is significant rain variation from year to year and these trends may continue with the wet season increasing and at the same time offsetting decreases in the drier months (Clay *et al.,* 2003).

Vulnerability Assessment Committees (VACs)[3] have highlighted how Southern African Development Community (SADC) member states were subjected to climate variations including droughts in the 2001/2002 and 2002/2003 seasons (Waiswa, 2003). Although drought has been commonly seen as the main climate issue in the region, there have been recent floods in Mozambique and extremely high rainfall in Malawi in the 2000 season (Clay *et al.,* 2003), floods in Southern Zambia (de Wit 2006) and some parts of Zimbabwe (Cooper *et al.,* 2006). For instance, these excessive rains in Malawi are considered to have played a leading role in the food crisis of 2002. Furthermore, links have been drawn between reduced production of annual cereal and maize and the South Eastern African rainfall index for Zimbabwe and for both Zimbabwe and Malawi for the country specific rainfall index (Clay *et al.,* 2003).

Cereal production, especially maize, is central to food security in Southern Africa. However, it is highly sensitive to drought and climatic variation and a striking relationship between production volatility and climate events has been established (Clay *et al.,* 2003). The agricultural productivity per unit of water ("crop per drop") in Africa has been documented as the lowest worldwide, and is far below its potential (Rosegrant *et al.*, 2002). Despite many research and development initiatives by development co-operations, Non-Governmental Organisations (NGOs) and local governments, Southern Africa still suffers from food insecurity and under nutrition and the chronic food emergencies that have afflicted Malawi, Mozambique, Zambia and Zimbabwe seem set to become more frequent (Twomlow *et al.,* 2008)

In southern Africa, among the countries worst affected by droughts are Zambia and Zimbabwe. Both countries, signatories to the United Nations Convention on Climate and Desertification (UNCCD), are facing the adverse effects of climate, which compromises growth in the agricultural sector and perpetuates subsequent degradation of the environment as rural households try to meet their livelihood needs (Twomlow *et al.,* 2008 and Waiswa, 2003). Drought relief is a common feature, almost every year, in the drier areas of both countries, as there appears to be an increasing trend towards a late start to the rainy season, prolonged mid-season droughts, and shorter growing seasons (Cooper *et al.*, 2007 and Love *et al.*, 2006). Using a case study of Zambia and Zimbabwe, this study, therefore, seeks to generate understanding on strategies that farmers employ to deal with the adverse effects of climate changes. This also becomes imperative as current knowledge of adaptation and

[3] SADC in 1999 established the Regional Vulnerability Assessment Committee (RVAC), a multi-agency committee to address the need to broaden and improve early warning information and vulnerability assessments at national (VAC) and sub national levels (RVAC) through spearheading critical improvements in food security and vulnerability analysis at country and regional levels respectively.

adaptive capacity is insufficient for reliable prediction of adaptations; it is also insufficient for rigorous evaluation of planned adaptation options, measures and policies of governments (IPCC, 2001:80).

About 70% of Zimbabwe's population derives its livelihood from subsistence agriculture and other rural activities, both of which are threatened by climate variability and change. The country is prone to droughts, which have become more frequent over the last two decades with devastating impacts on food security, health, and environmental degradation. Over the last ten years, the country's economy has stagnated due to droughts and macro-economic instability. Similarly, Zambia's economy is agriculture based, after the decline of mining in the post independence period (after 1964) and has also been under threat in the past 20 years. Drought frequency and intensity have rocked the country with further disturbances from the recent floods in the Southern part of the country. This is made worse as agriculture heavily relies on seasonal rain-fed agriculture, making the sector especially vulnerable to climate change (Chagutah, 2006; De Wit, 2006; Gandure & Marongwe, 2006 and Lynas, 2009).

Climate variability and change for Zambia and Zimbabwe is looming. By 2050, average temperatures over Zimbabwe will be 2–4°C higher and rainfall 10–20% less than the 1961-1990 baselines (Unganai, 2006). Simulation models show annual rainfall declining by 5–20% of the 1961-90 average by 2080 in all Zimbabwe's major river basins. Similarly, in Zambia temperatures are increasing at a rate of about 0.6°C per decade, which is ten times higher than the global and Southern African rate of increase in temperature. Agriculture, an important sector in both countries, has been identified as the sector most vulnerable to these climate changes. Given the similarities in the gloomy predictions of climate changes and differences in the economic performances of Zambia and Zimbabwe, what are the similarities and differences in farmer perceptions of threats, climate change impacts and subsequent adaptation processes in these countries?

The impacts of climate variability and change will require management at different levels, namely, mitigation strategies adopted by governments and environmental bodies (specifically to address greenhouse gas emission, increasing adaptive capacity of smallholder farmers, diversifying coping mechanisms and improving the reliability of information for managing climate risks. Farmers have a myriad of practices that help them overcome the vagaries of the harsh environment and allow them to sustain their livelihoods and actively manage their environment (Scoones *et al.,* 1996). There is, therefore, need for a comprehensive study to understand the coping and adaptive strategies that farmers employ and what factors influence these strategies in an attempt to secure livelihoods.

Previous climate change adaptation research on African countries has highlighted the importance of understanding farmer perceptions in order to understand how farmers respond to climate change (Deressa *et al.,* 2008; Grothmann & Patt, 2005; Nhemachena & Hassan, 2008; Patt & Gwata, 2002 and Vedwan & Rhoades, 2001). These studies illustrate that the way farmers perceive climate changes influences whether they will cope with or adapt to these changes, making it imperative to understand farmer perceptions as a prerequisite for adaptation. Furthermore, it is important to understand how farmers perceive risk in the face of climate change as these perceptions of risk are also considered to influence farmers' activities and planning decisions in responding to climate changes (Scoones *et al.,* 1996). Risk elements encompass both climate and non climate risks such as droughts, floods, macro economic conditions, crop failure, crop and livestock pests and diseases, input supply and pricing fluctuation, among others. Scholars have also documented these and other risk elements (Campbell *et al.*, 2002 and Moriarty & Lovell, 1998).

A myriad of socio-economic pressures, coupled with climate variability and change, may, therefore, weaken a country's capability to cope and adapt to long-term changes. The situation is worse for small-scale farmers who have to earn their livelihoods from farming. Given these scenarios, how do the rural poor farmers currently cope with the immediate vagaries of climate variability and change and adapt their farming systems to future threats of further climate change?

1.3 AIM AND OBJECTIVES OF THE STUDY

The overall aim of the study is to investigate current coping and adaptive strategies amongst smallholder farmers in Zambia and Zimbabwe and make recommendations for adaptation processes for future climate variability and change.

Specific objectives of this study are to:

- Investigate farmer perceptions of threats from climate variability and change and how these differ across countries
- Identify and analyze the impacts of climatic variability and change on farmer households in the two countries
- Identify coping and adaptation strategies to climate variability and change by farmers and investigate factors influencing these strategies across Zambia and Zimbabwe

1.4 OUTLINE OF THE THESIS

Chapter One has set out the research context by outlining the background and introduction to the study, stating the problem and presenting the objectives of this study. Chapter Two presents an exposition of literature related to climate change at different levels, that is, moving from climate change in the industrialised world down to climate change at the local level in developing countries. The same chapter also reflects on impacts, the nature and causes of climate change. Chapter Three presents a discussion on human vulnerability to environmental change. It further discusses environmental and climate change adaptation, the strategies that farmers have adopted across Africa and to what extent they have been successful. A detailed biographical overview of the selected sites in Zambia and Zimbabwe, that is, their geographical location, climate conditions, livelihoods and farming systems follows in Chapter Four. The methodological design of the study and the analytical framework for analyzing the results from this study are also presented in the same chapter. The presentation of results and their discussion in relation to the objectives of the study is done in Chapter Five. Chapter Six presents conclusions and recommendations drawn from the study.

CHAPTER 2: CLIMATE CHANGE CONTEXT

2.1 INTRODUCTION

Chapter Two highlights the climate change context in two parts. The first part presents 'the context of climate change' in four sub-sections. The first section of part one presents key concepts in the context of climate change. These concepts are 'climate variability', 'climate change' and 'climate impacts'. The second section traces the emergence of climate change science. To understand the context of climate change, it is necessary to trace the trajectories of climate change science to the present. Section three summarises the debates surrounding causes of climate change. There are different causes given for climate changes, and it is important in this thesis to understand what the debates around causes of climate change constitute both globally and in Africa. This section presents the distinction between natural and human induced causes of climate change. Observed and predicted climate changes are elaborated in the fourth section and these are presented first for the international context, for Africa and then for Zimbabwe and Zambia.

The second part of this chapter summarises impacts of climate change in the international context, in Africa and in Zimbabwe and Zambia on the following four sectors: health, water, the economy and agriculture. The selection of these sectors is by no means complete, but it is envisaged that these are the major sectors that relate to this study and that warrant to be singled out. Other sectors are discussed under the economy sector as elaborated on in this second part of the chapter.

2.2 CLIMATE CHANGE IN PERSPECTIVE

2.2.1 KEY CONCEPTS IN THE CONTEXT OF CLIMATE CHANGE

'Climate variability' and 'Climate change'

Although the distinction between 'climate change' and 'climate variability' has been brought out in many different ways, the common distinction is based on time scale. On the one hand, 'climate variability' is conceptualised as variations in the climate system over short time scales such as months, years or decades and on the other hand 'climate change' is conceptualised as longer term trends in mean climate variables of periods of decades or longer. While this is the suggested distinction in definitions of the concepts in question by the IPCC (Watson, 2001), UNFCCC advocates for a different distinction between the two concepts (Pielke, 1998 and Watson, 2001). An alternative definition by UNFCCC focuses on causes of variation in the climate and posits that 'climate variability' relates to natural variations in the climate and 'climate change' relates to human induced variations in the climate. In this thesis, the distinction between 'climate variability' and 'climate change' relates to the highlighted conceptualisation of time-scale.

'Climate change' is defined as a shift of climatic conditions in a directional incremental mode, with values of climatic elements changing significantly and as long-term weather patterns that describe a region (Unganai, 1996). Weather refers to the state of the atmosphere at a given time and place with respect to variables such as temperature, moisture, wind velocity and barometric pressure while climate refers to statistical weather information that describes the variation of weather at a given place for a specified interval such as 30 years (NSIDC 2010). Evidence of climate change could be detected over several decades (Houghton *et al.,* 1990). Climate change has been documented as one of the most challenging emerging problems facing the world in the 21st century (Houghton *et al.,* 1990 and O' Brien & Leichenko, 2000). The IPCC's Third and Fourth Assessment Reports (2001 & 2007) provide an assessment and evidence of variability and changes in global climate.

'Climate variability' can be understood in terms of the yearly changes identified when the seasonal rains start and the rainfall amounts recorded. It can also be understood as variations in the prevailing state of the climate on all temporal and spatial scales beyond that of individual weather events (O'Brien & Leichenko, 2000). In the same respect, 'climate variability' means the seasonal and annual variations in temperature and rainfall patterns within and between regions or countries (UNEP, 2002a). Variability may be due to natural internal processes within the climate system or to variations in natural or anthropogenic external forcing and depend on physical processes of the climate system (Waiswa, 2003). For Africa, it is determined by prevailing patterns of sea surface temperature, atmospheric winds, regional climate fluctuations in the Indian and Atlantic Oceans, and by the El Niño Southern Oscillation (ENSO) phenomenon - the natural shift in ocean currents and winds off the coast of South America which occurs every two to seven years. ENSO events bring above average rainfall to some regions and reduced rainfall to others.

Climate change impacts

Although substantial research has been undertaken to improve our understanding of complex and interwoven spheres of climate change, there are significant knowledge gaps regarding our "understanding of impacts likely to result from significant changes to present patterns of climate" (Wheaton, 1994:33). Knowledge gaps continue to exist at the level of impact analysis despite a growing number of country-level case studies (Tol *et al.,* 2004). Knowledge on local impacts is considered to be uneven and incomplete. This is the case because the bulk of research funding and human resources has been channelled towards developing and improving models of atmospheric climate change and this has deflected attention away from research on socio-economic impacts (Taylor & Buttel, 1992).

Early analyses of climate change impacts in the 1970s tended to be based upon the impact approach, in a rather simplistic one-way and non-interactive model which attributed the impacts upon an exposure unit directly and solely to climatic variation (Chiotti & Johnson, 1995). However, by the 1980s, there was a shift in focus as some scholars began to recognise that climate change effects were also influenced through interactions with other environmental and non-environmental factors (Garcia & Escudero, 1981) and that climate change impacts could occur and be measured throughout society and at various scales (Warrick & Bowden, 1981). Moreover, there is now recognition that climate change is taking place within a rapidly changing world and existing vulnerabilities are being modified and exacerbated by ongoing processes of economic globalisation (O'Brien & Leichenko, 2000). While a number of studies have been conducted on impacts of climate change on global agricultural trade (Fischer *et al.,* 1994; Reilly *et al.,* 1994), neither of these studies considered agricultural interactions with other economic sectors, or structural economic changes that might influence agricultural production, even in the absence of climate change (O'Brien & Leichenko, 2000).

Both positive and negative climate change impacts may be experienced at different levels (Boko *et al.,* 2007). This is considered to be the case for two reasons: Firstly, global circulation models project spatial differences in the magnitude and direction of climate change and, secondly, even within a region experiencing the same characteristics of climate change, the impacts are likely to vary because some ecosystems, sectors, or social groups are more vulnerable to climate change than others (O'Brien & Leichenko, 2000). In middle and higher latitudes, global warming will extend the length of the potential growing season, allowing earlier planting of crops in the spring, earlier maturation and harvesting, and the possibility of completing two or more cropping cycles during the same season (Rosenzweig & Hillel, 1995).

However, at a global scale, positive and negative effects are likely to be distributed unevenly, with the most severe negative impacts occurring "in regions of high present-day vulnerability that are least able to adjust technologically to such effects" (IPCC, 2001 and Parry, 1990:1). For instance, a study that was done by Seo and Mendelsohn (2006a) shows that higher temperatures are beneficial for small farms that keep goats and sheep because it is easy to substitute animals that are heat-tolerant. By contrast, large farms are more dependent on species such as cattle, which are not heat-tolerant. In addition, beneficial effects can be identified for some regions and social groups, but they are expected to diminish as the magnitude of climate change increases. Also, many identified adverse effects are expected to increase in both extent and severity with the degree of climate change. When considered by region, adverse effects are projected to predominate for much of the world, particularly in the tropics and subtropics (IPCC, 2001).

Moreover, in climate change discussions, scientists and policymakers are reluctant to recognise, address and discuss the existence of both positive and negative impacts, especially the positive ones, for such discussions are considered to be divisive and counter the efforts to gain a global consensus on climate change (Glantz, 1995 and Schneider, 1989). For instance, climatically, the gradual change view of the future assumes that agriculture will continue to thrive and growing seasons will lengthen. Northern Europe, Russia, and North America will prosper agriculturally while southern Europe, Africa, and Central and South America will suffer from increased dryness, heat, water shortages, and reduced production. Overall, global food production under many typical climate scenarios increases (Schwartz & Randall, 2003). However, for this thesis, it is important to engage in a discussion on positive and negative impacts from climate change, based on the assumption that farmers may be able to capitalise on the positive aspects and advantages from climate change to improve their livelihoods. In addition, climate impact assessments inevitably point to winners and losers, and the perception alone of winning or losing can significantly influence climate negotiations (Rosenzweig & Hillel, 1995 and UNEP, 1993).

2.2.2 THE HISTORY OF CLIMATE CHANGE SCIENCE

As early as the 1800s, scientists had already started noting changes in the climate. The realisation that the Earth's climate might be sensitive to the atmospheric concentrations of gases that create a greenhouse effect is more than a century old (Fleming, 1998 and Weart, 2003). Scientists such as Fourier (French) and Arrhenius (Swedish) explained the Earth's greenhouse effect and the role played by some atmospheric gases such as CO_2 and methane (CH_4) in warming our planet (Fleming, 1998). Around the same time, Arrhenius, together with Chamberlain, an American scientist, realised that the burning of fossil fuels could lead to global warming. Arrhenius gave a prediction around 1896 on greenhouse gases suggesting that a 40% increase or decrease in the atmospheric abundance of the trace gas CO_2 might trigger glacial advances and retreats. This was indeed confirmed one hundred years later with the assertion that CO_2 did indeed vary by this amount between glacial and interglacial periods (IPCC, 2007). From the 1900s, systematic measurements of global surface temperatures and atmospheric CO_2 concentrations have identified a remarkable increasing trend (Callender, 1938). Investigations of temperatures in the more distant past show an abnormal increase in temperatures over the past fifty years that is beyond the natural variation found in more than 1000 years (Callender, 1938; Chiotti & Johnson, 1995 and Ohshita, 2007).

There is increasing evidence from work that has been carried out by the IPCC[4] over nearly two decades to cement the conclusion that global warming and the subsequent climate changes are largely due to human activities. This has been done through a formal review process involving national governments and climate experts where four successive assessment reports[5] were issued by the IPCC (Ohshita, 2007). In the IPCC's second assessment report (1995:5), a cautious conclusion regarding the influence of human activities on climate change was issued: "The balance of evidence suggests a discernible human influence on global climate." This statement drew sharp criticism from those reluctant to acknowledge the climate change problem (Ohshita, 2007). The criticism emphasised that modern civilization will either adapt to whatever weather conditions we face and that the pace of climate change will not overwhelm the adaptive capacity of society, or that our efforts such as those embodied in the Kyoto protocol[6] will be sufficient to mitigate the impacts (Schwartz & Randall, 2003). However, a more strengthened conclusion followed in the third assessment report (IPCC, 2001:8) which stated that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". In addition, the world is increasingly facing weather related disasters - more hurricanes, monsoons, floods, and dry-spells – in regions around the world (Schwartz & Randall, 2003).

The fourth and most recent report left no doubt about the certainty that human emissions of greenhouse gases are the cause of observed global warming and that "warming of the climate system is unequivocal" (IPCC, 2007:10). Four major conclusions reached in the fourth assessment report are central to this study. First, that the global climate system is warming, second, that climate change is human induced, third, that climate change impacts are an existing reality and fourth, that climate change solutions are available and are needed immediately (IPCC, 2007 and Ohshita, 2007). Moreover, the scope and magnitude of current climate risks are well known and action is urgently needed (Huq *et al.,* 2006 and UNDP, 2004).

2.2.3 DEBATES SURROUNDING CAUSES OF CLIMATE CHANGE

There continues to be considerable debate regarding the causes of climate change, that is, whether it is induced by anthropogenic activities or simply within the range of natural variability. While there is no consensus on the causes of climate change, there is a general

[4] The IPCC was established by the World Meteorological Office (WMO) and UNEP in 1988. Its mandates included identification of gaps in knowledge on climate changes and potential impacts, identification of relevant information for evaluation of policy implications. IPCC was also tasked to review planned international policies that deal with GHG issues and do assessments on these policies and make recommendations to governments and NGOs for socio-economic and environmental development (IPCC 2007).

[5] These reports were published in 1990, 1995, 2001 and 2007.

[6] The Kyoto Protocol (1997) is an agreement to a 5.2 % reduction in greenhouse-gas emissions by about 2010 (relative to 1990), and constant emissions thereafter. These targets relate to the annex 1 countries. These are 38 highly industrialised countries and countries undergoing the process of transition to a market economy.

consensus regarding future climates and the potential implications for agriculture (Chiotti & Johnson, 1995). While climate change in the IPCC's usage refers to any change in climate over time, whether due to natural variability or as a result of human activity, this usage differs from that of UNFCCC where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods (Boko *et al.*, 2007). This thesis, adopts the latter definition as the guiding principle to understanding farmers' perceptions and responses to climate variability and change. However, what is of importance is that regardless of the causes of climate change, both IPCC and UNFCCC concur that there have been noticeable changes in the global climate over the last 50 years.

Natural causes

Natural causes of climate change that have been cited include processes of heat storage in the atmosphere which causes the earth climate to change. Accumulation of greenhouse gases in the atmosphere has occurred naturally in the history of the earth and these have caused changes in climate. Stratospheric aerosols from explosive volcanic eruptions lead to negative forcing, which lasts a number of years. Several major eruptions occurred in the periods 1880 to 1920 and 1960 to 1991. However, the combined change in radiative forcing of the two major natural factors, namely solar variation and volcanic aerosols, is estimated to be negative for the past two to four decades (IPCC, 2001). Changes in the amount of heat from the sun and how heat is stored in the oceans have also contributed to the noticeable climate changes. Large volcanic eruptions can also cause the earth to cool over a couple of years (CCIR-NYC, 2005; Practical Action, 2008 and Sutton, 2007).

It is not clearly and well understood what causes low rainfall in Southern Africa and a great deal of uncertainty remains. The droughts of 1991/92, 1994/95 and 1997/98 were all associated with ENSO and climatologists have established a relationship that is significantly high between ENSO and inter-annual variations in rainfall in Southern Africa (Clay *et al.*, 2003). The ENSO phenomenon is a major cause of the high inter-annual variability of climate over much of Southern Africa (Ropelewski & Halpert, 1987 and Tyson, 1986) and predictions are that the ENSO phenomenon will continue to occur in future as it does today (Unganai, 1996). However, not all El Nino events bring low rainfall as in some extremely low rainfall years; links with the ENSO have not been established. In addition, more recent reports attribute climate change largely to anthropogenic activities (IPCC, 2007).

Human induced causes

Scholars concur that climate change is the slow change in the composition of the global atmosphere, which is caused directly and indirectly by various human activities in addition to natural climate variability over time. However, the majority of the world's scientists who study this topic conclude that expected climate change would differ from previous climate change because of human activities (Sutton, 2007). The IPCC (2001 & 2007) reports concluded that climate change, particularly global warming, is largely due to human activities. It has been documented that human activities increase greenhouse gases in the atmosphere by introducing new sources or removing natural sinks such as forests and through human activities such as burning fossil fuels, burning wood and land tillage practices. While sources are processes and activities that release greenhouse gases, sinks are processes, activities or mechanisms that remove greenhouse gases. A balance between sources and sinks determines the levels of greenhouse gases in the atmosphere (Sutton, 2007).

The atmospheric concentrations of key anthropogenic greenhouse gases; CO_2, CH_4, nitrous oxide (N_2O), and tropospheric ozone (O_3) reached their highest recorded levels in the 1990s primarily due to the combustion of fossil fuels, agriculture, and land-use changes (IPCC, 2001 & 2007). Carbon dioxide is the major greenhouse gas produced by humans, which is having the single greatest effect on climate change. CO_2 annual emissions have grown by about 80% between 1970 and 2004, i.e. from 21 to 38 gigatons (Gt), and represented 77% of total anthropogenic GHG emissions in 2004. The rate of growth of CO_2 emissions was much higher during the recent 10-year period of 1995-2004 than during the previous period of 1970-1994. The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry, while residential and commercial buildings, forestry (including deforestation) and agriculture sectors have been growing at a lower rate. Since the start of the industrial revolution around 1750, some 270 billion tons of carbon have been released globally from the consumption of fossil fuels and cement production. Half of these emissions have occurred since the mid 1970s, although there was a slight decline of 0.3% between 1997 and 1998 (IPCC, 2007 and Marland *et al.,* 2000).

Human population growth has led to increasing demands for energy and land resources. Through the burning of fossil fuels to produce energy for industrial use, transportation, and domestic power, and through land-use change for agriculture and forest products, humans have been altering the Earth's energy balance. Scientists believe that these changes may have already begun to alter the global climate (Rosenzweig & Solecki, 2009). The observed widespread warming of the atmosphere and the ocean, together with ice mass loss, support the conclusion by the IPCC (2007:39) that "it is extremely unlikely that global climate change of the past 50 years can be explained without external forcing and very likely that it is not due to known natural causes alone". However, there are limitations and gaps in the available analyses in terms of the number of systems and length of records and locations considered, which prevent more complete attribution of the causes of observed natural system responses to anthropogenic warming. Difficulties remain in simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish changes expected due to external forcing. At the regional scale, other non-climate factors such as land-use change, pollution and invasive species are influential and the magnitude of CO_2 emissions from land-use change and CH_4 emissions from individual sources remain as key uncertainties (IPCC, 2007).

Nevertheless, there is consistency between observed and modelled changes in several studies and spatial agreement between significant regional warming and consistent impacts at the global scale. This is sufficient to conclude with high confidence that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems (IPCC, 2007). In addition, the annual CO_2 concentration growth rate was larger during the last 10 years (1995-2005 average: 1.9 ppm per year) than it has been since the beginning of continuous direct atmospheric measurements (1960-2005 average: 1.4 ppm per year), although there is year-to year variability in growth rates. Therefore, due to these current trends, impacts of global warming such as temperature extremes, heat waves and heavy rains will continue to escalate in frequency, ice caps will continue to melt and seas will continue to rise (IPCC, 2007 and Practical Action, 2008).

Africa's CO_2 emissions from use of fossil fuels are low in relation to other regions, in both absolute and per capita terms (UNEP, 2002a). Despite the region's total emissions having risen to 223 million metric tons of carbon in 1998 (eight times the level in 1950). This is still less than the emissions for the United States, Mainland China, Russia, Japan, India, or Germany. Per capita emissions also increased three-fold over the same period, reaching 0.3 metric tons of carbon, only 5.7% of the comparable value for North America. Only a small number of African countries account for the bulk of the region's emissions from fossil fuels. For instance, South Africa accounts for 42% with another 35.5% coming from Egypt, Nigeria and Algeria combined (Marland *et al.* 2000). The industrialised annex I[7] countries together account for about 57% of present global carbon emissions. However, there are predictions that they will produce only 25 per cent of the emissions growth over the next 20 years. Most future growth in emissions is expected to occur in the fast-developing regions of Asia and Latin America, which are not signatories to the Kyoto Protocol. Although Africa contributes very little to global GHG emissions, the region is highly susceptible to the impacts of climate change because of its dependency on agriculture and limited financial resources for development of mitigation strategies. Greater variability and unpredictability of temperature and precipitation cycles in Africa resulting from climate change are predicted to increase the frequency of drought and flood occurrences. Therefore, grain yields are expected to decline and climate change is expected to pose a threat to human health (IPCC, 2001b).

[7] There are 40 Annex I countries and the European Union is also a member. These countries are classified as industrialised countries and countries in transition

Emissions of GHGs by Southern Africa, especially South Africa, are higher than those for other sub-regions of Africa. Although they represent only 2% of the world total, this is a cause for concern and the sub-region's emissions are projected to rise as countries develop, including a threefold increase in Zimbabwe over the next 50 years (Southern Centre, 1996). Moreover, South Africa already has a net positive GHG emission level, and thus accounts for the majority of emissions from the sub region and 42% of all emissions from Africa (Marland *et al.,* 2000). This is the case as the level of industrialization in Southern Africa is high compared to other parts of Africa and a greater proportion of Southern Africa's primary energy comes from fossil fuels, in the form of coal and petroleum (UNEP, 2002a).

2.2.4 OBSERVED AND PREDICTED CLIMATE CHANGES

Global climate change

Cited changes that have been noted in the historical climate record for Africa and the rest of the world indicate warming of temperatures during the 20th century, changes in precipitation across the globe, changes in sea level and ice and snow extent (Boko *et al.,* 2007 and IPCC, 2001 & 2007). Moreover, eleven of the last twelve years– that is the period from 1995 to 2006 have been observed as the warmest years since 1850. The temperature increase has been considered to be widespread over the globe and is greater at higher northern latitudes. In addition, average Arctic temperatures have increased at almost twice the global average rate in the past 100 years (IPCC, 2007). The global temperature has risen by 0.6°C in the period between 1975 and 2004 (German Advisory Council on Global Change [WBGU] 2008). Reports further indicate that land temperatures have increased faster than ocean temperatures. Observations made since 1961 show that the average temperature of the global oceans has increased to depths of 3000m and that 80% of the heat being added in the climate system has been taken up by the oceans (IPCC, 2007). Increases in sea level and the melting of polar ice are consistent with warming. For instance, global average sea level rose at an average rate of 1.8 mm per year between 1961 and 2003 and at an average rate of about 3.1 mm per year from 1993 to 2003. However, it remains unclear whether the latter rate reflects variation during periods of ten years each or an increase in the longer term (IPCC, 2001 &, 2007).

Based on the four climate scenarios defined in the preliminary Special Report on Emissions Scenarios (SRES) of the IPCC, namely B1, B2, A1 and A2, predictions are that there will be yield increases in global-mean temperature of between 1.3°C and 4.6°C by 2 100 representing global warming rates of between 0.1°C and 0.4°C per decade. The development of the global temperature is foreseeable, for instance, the rise in temperature compared to 2005 will likely be in the range 0.4-0.6°C. In the long-term, with no effective climate protection measures such as stabilizing the greenhouse gas concentrations, it is anticipated that global warming can only be restricted to a maximum of 2°C above pre-industrial levels. However, a temperature rise of between 2°C and 7°C above pre-industrial levels may be expected (IPCC, 2007a and WBGU, 2008). It is important to also note that some regions and continents are likely to experience much greater warming than the global mean. One of the most striking consequences of a warming climate will be the rise in sea-level. Scenarios suggest a future global-mean sea-level rise of between 2 cm and 10 cm per decade, compared to an observed rise over the last century of between 1 cm and 2 cm per decade. The largest contribution to this rise in sea-level comes from the expansion of warmer ocean water, a slow inexorable process that will ensure that the world's sea-level continues to rise for centuries to come (Hulme & Sheard, 1999).

Globally, the effects of the warmer climate would include an increase in rainfall. In essence, there would be a 1-2% increase in rainfall for every degree of warming (IPCC, 2007b). This would be caused by the subsequent increase in evaporation and the increase in the amount of water vapour in the air. However, it is important to note that precipitation will vary by regions. There is already evidence from observations that the effects of global warming amplify the water cycle: evaporation in the sub-tropics is increasing and this is leading to heavier precipitation in the medium and high latitudes (WBGU, 2008). In recent decades, a distinct increase in the intensity of tropical cyclones has been noted. This is primarily because of the increase in tropical ocean temperatures, which have shown a similar pattern to that of global mean temperature (Emmanuel, 2005 and Hoyos *et al.,* 2006). In the same respect, in the 20th century, the global sea-level rose by 15-20 cm. without mitigation, a global sea-level rise of around 30 cm by the year 2100 can be expected (IPCC, 2007b) and possibly significantly more (Rahmstorf, 2007).

Climate change in the international context

The temperature increase in Europe over the last 100 years is about 0.95°C, which is higher than the global average (CRU, 2003 and Jones & Moberg, 2003). The warmest year to date in Europe was 2000, and the next seven warmest years all occurred in the last 14 years (European Environment Agency [EEA] 2004). Of particular interest is the fact that there is a wide variation in increasing temperatures across the continent. The warming has been greatest in northwest Russia and the Iberian Peninsula (Klein *et al.,* 2002 and Parry, 2000). In line with the global trend, temperatures are increasing in winter more than in summer (+ 1.1°C in winter, + 0.7°C in summer) and this is resulting in milder winters and a decreased seasonal variation. Similarly, over the 20th century, the average annual USA temperature has risen by almost 0.6°C and there are indications that the warming in the 21st century will be significantly larger than in the 20th century with temperatures in the USA rising by about 3-5°C on average in the next 100 years, which is more than the projected global increase. Specifically, the coastal northeast, the upper Midwest, the southwest, and parts of Alaska have experienced increases in the annual average temperature approaching 2ºC over the past 100 years, while the rest of the region has experienced less warming (NAST, 2000). These global changes have been mirrored in Australia, where average temperatures have increased by about 0.7°C since 1910 (Preston & Jones, 2006).

Similarly, observed decreases in snow and ice extent are also consistent with warming of the atmosphere. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7% per decade, with larger decreases in summer of 7.4% per decade. In addition, mountain glaciers and snow cover on average have declined in both hemispheres. Glaciers in eight out of the nine European glacier regions are in retreat, which is consistent with the global trend. From 1850 to 1980, glaciers in the European Alps lost approximately one third of their area and one half of their mass. Since 1980, another 20–30% of the remaining ice has been lost. In addition, the hot dry summer of 2003 led to a loss of 10% of the remaining glacier mass in the Alps (Dyurgerov, 2003). Current glacier retreat in the Alps is reaching levels exceeding those of the past 5 000 years and it is very likely that the glacier retreat will continue. It is estimated that by 2050, about 75% of the glaciers in the Swiss Alps are likely to have disappeared (Haeberli, 2003 and IPCC, 2001).

For precipitation, the situation is more complicated. There is notable temporal and spatial variability in terms of rainfall (see Hulme *et al.*, 2005). Trends in precipitation in many large regions covering the period 1900 to 2005 show that while on the one hand, precipitation increased significantly in eastern parts of North and South America, northern Europe and northern and central Asia, on the other hand, precipitation declined in the Sahel, the Mediterranean, Southern Africa and parts of southern Asia. Globally, the area affected by drought has likely increased since the 1970s (IPCC, 2007). As an average overall global land areas, annual precipitation increased by 2% between 1900 and 2000. In Europe, this increase was considerably larger (IPCC, 2001; Klein *et al.,* 2002 and Parry, 2000). However, there is a significant difference between seasons and a contrasting picture across the continent. Annual precipitation increased over northern Europe by 10–40% in the period 1900–2000, whereas parts of southern Europe experienced a 20% precipitation decrease (IPCC, 2001; Klein *et al.,* 2002; National Oceanic and Atmospheric Administration [NOAA] 2003). In the winter season, especially, southern and eastern Europe became drier, while many parts of north-western Europe became wetter (Parry, 2000 and Romero *et al.,* 1999).

In the USA, precipitation has increased nationally by 5 to 10%, mostly due to increases in heavy downpours. These trends are most apparent over the past few decades. It is estimated that more extreme precipitation and faster evaporation of water will occur, leading to greater frequency of both very wet and very dry conditions. Precipitation increases have been especially noteworthy in the Midwest, southern Great Plains and parts of the West and Pacific Northwest while decreases have been observed in the northern Great Plains (NAST, 2000).

Precipitation in Western Australia and along Australia's east coast has declined since the mid-20th century, but has increased in the northwest. Australia has also experienced an increase in extreme rainfall events, particularly during winter (Preston & Jones, 2006).

Climate change in Africa

For Africa, there has been a warming of approximately 0.7°C across most of the continent in the 20th century. Although these warming trends seem to be the same over the African continent, climate changes are not always uniform. For instance, there have been warming rates of 0.29°C in the African tropical forests in ten year periods (Malhi & Wright, 2004) and 0.1°C to 0.3°C in South Africa (Kruger & Shongwe, 2004). In the same respect, in South Africa and Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures and between 1961 and 2000, there was an increase in the number of warm spells over Southern and Western Africa, and a decrease in the number of extremely cold days (New *et al.,* 2006). A rate of warming of about 0.05°C per decade in Southern Africa has been observed during the present century (Hulme, 1996 and Jain, 2006). The six warmest years in this century in Southern Africa have all occurred since 1980. The sub-region is expected to experience a mean temperature rise of 1.5°C and increased rainfall variability and insecurity (Hulme, 1996). Even more disturbing is the evidence of a looming average global temperature increase with warm temperatures ranging from 0.2 to 0.5°C per decade. This warming is greatest over the interior of semi-arid margins of the Sahara and central Southern Africa (IPCC, 2001). However, trends in decreasing temperature from weather stations located close to the coast or to major inland lakes have been observed in Eastern Africa (King'uyu *et al.* 2000). This points towards the implication that there is need to consider that climate changes vary by location rather than blanketing changes as being the same over the continent. For instance, there may be a global increase in average temperatures, but impacts of this global warming vary at lower scale, by country and region.

While inter-annual climate variability has been observed over most of Africa, multiple ten year periods of climate variability in some regions have also been observed. On the one hand, observations in Western Africa indicate there has been climate change in the form of a decrease in mean annual rainfall since the end of the 1960s. For instance, between 1931 and 1960 and 1968 and 1990, there was a decrease of 30 to 40% (Chappell & Agnew, 2004; Dai *et al.,* 2004 and Nicholson *et al.,* 2000). In the same respect, there was a decrease in mean annual rainfall in the tropical rain forest zone of 4% in West Africa, 3% in North Congo and 2% in South Congo for the period 1960 to 1999 (see Malhi & Wright, 2004). On the other hand, there has been a significant increase in rainfall along the Guinean Coast in the last 30 years. While there has been a decrease in rainfall across most parts of the Sahel, an increase in rainfall has been registered in East and Central Africa (IPCC, 2001). On the ten year period time scale, Eastern Africa has been experiencing an increase in rainfall over the Northern sector and a decrease in rainfall over the Southern sector (Schreck & Semazzi, 2004).

In contrast, there are regions such as Southern Africa where no long-term trends in climate change, especially in rainfall, have been noted (Boko *et al.*, 2007 and Richard *et al.,* 2001). In some cases though, data inadequacies may mean that it cannot be determined if there have been changes (IPCC, 2007). Instead, inter-annual variability is what has been observed in the post 1970 period. This variability has manifested in higher rainfall anomalies and more intense and widespread droughts that have been reported (e.g., Boko *et al.,* 2007; Fauchereau *et al.,* 2003 and Richard *et al.*, 2001). Including evidence of changes in seasonality and weather extremes (Boko *et al.,* 2007; New *et al.,* 2006 and Tadross *et al.*, 2005a) significant increase in heavy rainfall events has been observed in some parts of Southern Africa that include Angola, Zambia, Namibia, Mozambique and Malawi (Boko *et al.*, 2007 and Usman & Reason 2004). According to simulated studies, Southern Africa's precipitation will decrease by 5-20% in all major river basins of the region except the Congo where precipitation is expected to increase by 10% (Chigwada, 2004).

The rainfall in the southern African region has been decreasing in the last 25 years, but a lack of long-term trends in climate changes in Southern Africa implies that there could be less of climate change and more of climate variability in some areas in this region (Hulme, 1996). In the same context, it is important to note that there is a dearth of studies in the region to shed more light and provide data which can be used to draw conclusions on climate variability and change. However, it is important to acknowledge that adaptation in climate variability scenarios can be and has been used as a proxy for adaptation to climate change (Parry *et al.,* 1999). A community's coping and adaptive capacities in the face of climatic variability and extremes are used as proxy for its level of coping and adaptive capacity for future climate change. Similarly, in the Third Assessment Report (TAR) of the IPCC (2001), it is argued that experience with adaptation to climate variability and extremes can be drawn upon to develop appropriate strategies for adapting to anticipated climate change (Parry *et al.,* 1999 and Usman & Reason, 2004).

Climate change in Zimbabwe and Zambia

Zimbabwe is now a warmer country than it was at the beginning of the twentieth century (Mano & Nhemachena 2006). The annual-mean temperature has increased by about 0.4°C since 1900, and the last decade has been the warmest in this century. This warming has been greatest during the dry season. During the wet season, day-time temperatures have warmed more than night-time temperatures (Hulme & Sheard, 1999). Daytime temperatures over Zimbabwe have risen by up to 0.8°C from 1933 to 1993, which translates to a 0.l°C rise per decade (Unganai, 1996). Zimbabwe is expected to warm somewhat more rapidly in the future than the global average. In model scenarios, annual warming reaches about 0.15°C per decade under the B1-low scenario, but this rate of warming increases to about 0.55°C per decade for the A2-high scenario. Moreover, rates of warming are expected to be slightly greater than this during the dry season and slightly less during the wet season. By 2050 temperatures and rainfall over the country will be 2–4°C higher and 10–20% less than the 1961-1990 baselines respectively (Zimbabwe Initial National Communication [ZINC] 1998).

There has been an overall decline of nearly 5% in rainfall across Zimbabwe during the 20th century, although there have also been substantial periods - for example, the 1920s, 1950s and 1970s - that have been much wetter than average. The early 1990s witnessed probably the driest period in the 20th century, a drought almost certainly related to the prolonged El Niño conditions that prevailed during these years in the Pacific Ocean (Hulme & Sheard, 1999). Zimbabwe was characterised by low precipitation during the late 1920s to 1949, late 1950 to about 1972 and from 1980 to present (Unganai, 1996). The decade 1986-1995 in Zimbabwe was about 15% drier than average (Hulme & Sheard, 1999). In terms of precipitation in Zimbabwe, of the 14 years from 1990/1991 to 2003/2004, at least ten years in each agro-ecological zone had below normal rainfall (Gandure & Marongwe, 2006). Model experiments predict annual rainfall decreases across Zimbabwe in the future. This decrease will occur in all seasons, but predictions are more conclusive for the early and late rains than for the main rainy season months of December to February. Furthermore, by the 2080s, there will most likely be annual rainfall averages between 5% (B1-low scenario) and 18 % (A2-high scenario) less than the 1961-90 average.

The ENSO is one of the main causes of climate variability for many tropical regions, especially for Zimbabwe. For example, since about 1976, there has been a tendency for negative (El Niño) warm phases of ENSO to dominate. This period has seen very strong El Niños in 1982/83 and 1997/98 and a prolonged El Niño between 1991 and 1994, events which are considered to have been partly caused by global warming (Hulme & Sheard, 1999).

For Zambia, the observed temperature from 32 meteorological stations in this country was analysed to detect trends in temperature change over last 30 years. The mean temperatures computed for the agro-ecological zones for three time periods, November–December, January–February and March–April, indicate that the summer temperature in Zambia is increasing at the rate of about 0.6°C per decade, which is ten times higher than the global or Southern African rate of increase of temperature (Chigwada, 2004; De Wit, 2006; Hulme, 1996 and Jain, 2006). The rate of increase is highest in November–December as compared to other periods across all agro-ecological zones.

The annual rainfall anomalies from the 1970–2000 annual averages were computed using observed data from all 32 meteorological stations in Zambia for the agro-ecological zones.

These annual rainfall anomalies indicate that of the 14 years from 1990/1991 to 2003/2004, at least ten years in each agro-ecological zone had below normal rainfall. We further note that the variability in annual totals across the three agro-ecological zones has not been uniform. The southern zone (Zone I) has experienced more severe dry seasons than the central zone (Zone II) in the last 20 years. Moreover, Zambia has had some of its worst droughts and floods in the last two decades (De Wit, 2006). Southern Zambia experienced severe floods in the period 2007 to 2008. In a study done in Southern Zambia by Kurji *et al.* (2006) with a focus on the exploratory analysis of daily rainfall data for evidence of climate change, while there is an indication of a slight trend to reduced annual and seasonal rainfall over the last 30 years, there is no obvious indication of more variation in the recent years than in the past. In this regard, the climate change has resulted in more variability, rather than a change in the mean. Moreover, while there is a slight trend to lower total seasonal rainfall and a lower number of rainy days over the years; the average amount of rainfall per rainy day, on the other hand, does not seem to have been affected.

As is the case in Zimbabwe, the ENSO phenomenon is now recognised as the major factor in determining precipitation patterns in Zambia especially during the summer rainfall, October to April. ENSO affects International Tropical Convergence Zone (ITCZ) and Congo Air Boundary (CABS), the main rain bearing mechanisms. The opposite phenomenon, La Nina, is considered to bring more rainfall, which normally results in floods. In the same respect, the ITCZ phenomenon is contrasted by the Botswana Upper High Influence (BUHI) which controls drought episodes and uneven rainfall distribution. BUHI creates an unfavourable condition for rainfall by pushing the rain-bearing ITCZ and active westerly cloud bands out of the region, Zimbabwe and Zambia (Chigwada, 2004).

2.3 CLIMATE CHANGE IMPACTS

This section presents the impacts that are experienced by different sectors, namely; health, water, the economy and agriculture at different levels. The first level is the international context which covers all other regions except Africa, followed by Africa and then Zambia and Zimbabwe. The selection of sectors presented in this section is not exhaustive, but does identify the specific sectors that are within the interests and scope of this study. These sectors are the ones that relate to the aim and objectives of this study which is centred on impacts of climate change on agriculture. The importance of water to agriculture has already been highlighted. Health issues for both farmers and livestock are also come into play critical to subsistence farming. Since agriculture has already been documented as the backbone of the economies of many African countries, it becomes important for this discussion to include the economy as a sector impacted by climate change. This, by no means implies that other sectors are not impacted by climate change and variability. Sectors such as tourism and the biosphere and energy are subsumed in a brief discussion under the economy sector. Though important, forestry and fisheries, the industrial and tourism sectors are also affected by climate change, but have not been widely researched and, therefore, are poorly understood (IPCC, 2007b). There are remarkably few studies available that examine the impacts of climate change on energy use in Africa, particularly for the energy sector (Boko *et al.,* 2007)

2.3.1 IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH

The international context

Because human health is intricately bound to weather and the many complex natural systems it affects, it is possible that projected climate change will have measurable impacts, both beneficial and adverse, on health (NAST, 2000). The impact of climate change on human health in developed countries is generally evaluated with respect to heat wave-related health problems, tick-borne diseases and flooding (EEA, 2004). There has been an observed increase in health impacts in recent decades and they are projected to escalate further due to projected rises in temperature. Episodes of extremely high temperatures manifested in heat waves also have significant impacts on health. Heat waves were experienced across the European continent at various periods and they had devastating effects. While in greater London, heat waves in July 1976 and July–August 1995 were associated with a 15% increase in mortality, a major heat wave in July 1987 in Athens was associated with 2 000 excess deaths (Katsouyanni *et al.,* 1993; McMichael & Kovats, 1998 and Rooney *et al.,* 1998).

Similarly, the heat wave in the summer of 2003 resulted in an estimated 20 000 excess deaths, particularly among the aged population in France, Italy, Spain, Portugal and other countries (Empereur-Bissonet, 2004). The heat wave of 2003 showed that many countries are not sufficiently prepared for such events, and that there is a need to take preventive action and to monitor improvements. Moreover, analysis of more recent river flooding in the UK shows that mental health problems are the most important health impact among flood victims due to experience of personal and economic loss and stress. It is expected that the number of people at high risk of coastal or river floods would increase from the current 1.6 million to 2.3-3.6 million by the 2080s (Department of Trade and Industry [DTI] 2004).

In the USA, although certain populations are at greater risk, much of the USA's population is protected against adverse health outcomes associated with climate conditions such as extreme heat and cold. This is the case as there has been an increase in households with central heating systems and air conditioning facilities. However, episodes of extreme heat already pose a health threat in parts of the USA. Annually in the USA, an average of about 400 deaths are directly attributable to heat (Centre for Diseases Control (CDC) 2001 & 2005b), and an average of nearly 700 deaths are directly attributable to cold (CDC, 2005a). For instance, following a five-day heat wave in 1995 in which maximum temperatures in

Chicago, Illinois ranged from 93 to 104ºF (33 to 40°C), the number of deaths increased to 85% over the number recorded during the same period of the preceding year. At least 700 excess deaths were recorded, most of which were directly attributable to heat. The elderly, young children, the poor, and people who are bedridden, on certain medications, or who have certain underlying medical conditions are at particular risk. However, the net effect on winter mortality from climate change is extremely uncertain.

In addition to heat-related mortality, there have been infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid-latitudes, both of which have increased the incidence of disease in the specific areas (IPCC, 2007). Although there is controversy about the incidence and continuation of significant mental problems such as post traumatic stress disorder following disasters, a rise in mental disorders has been observed following several natural disasters in the USA. It is also estimated that current exposures to air pollution have serious public health consequences; ground-level ozone can exacerbate respiratory diseases and cause short-term reductions in lung function and exposure to particulate matter can aggravate existing respiratory and cardiovascular diseases. This can alter the body's defence systems against foreign materials and damage lung tissue, leading to premature death and possibly cancer (NAST, 2000).

Since 1995 there has been a 35% increase in the size of tropical cyclones from the Gulf compared to the previous active period of storms from 1948-1964, which has led to a doubling in the number of tornadoes produced per storm in the USA (NAST 2000). The number of hurricane-induced tornadoes during the 2004 and 2005 hurricane seasons is unprecedented in the historical record since 1920 (National Science Foundation [NSF] 2009). For instance, on 29 August, Hurricane Katrina pounded the U.S. Gulf Coast causing widespread destruction and flooding. Hundreds of thousands of people throughout Louisiana, Mississippi and Alabama were forced to evacuate their homes. One of the hardest-hit areas is the city of New Orleans, which was almost completely flooded when its system of protective levees failed. Hundreds of people suffered some type of gastro-intestinal illness. The ideal breeding ground for such diseases could be found in the Superdome and Convention Center, where crowds of people were packed for days with no sanitation. Other diseases that affected residents at this time included influenza and other respiratory diseases (Levine 2005).

The effects of climate change on heat related mortality in Australia suggest that increases in temperature combined with population growth may result in an increase in heat-related deaths over the next century after adjusting for decreases in cold and ozone-related mortality. In addition, climate change could increase the risk of food and water-borne illnesses (Preston & Jones, 2006). However, due to its relatively high adaptive capacity, the vulnerability of Australia's public health sector is relatively low and it has been found that water borne illnesses can be addressed through appropriate infrastructure management and food handling. It is still important to consider these impacts as one can identify demographic groups such as Australia's aboriginal population with elevated vulnerability to health challenges due to limited access to financial and public health resources.

Impacts on Africa

Climate change impacts on health are more deep-rooted and diverse in Africa than they are in the developed countries cited in the preceding paragraphs. In recent years, it has become clear that climate change has direct and indirect impacts on diseases that are endemic in Africa. Following the 1997–1998 El Niño events, malaria, Rift Valley Fever (RVF), and cholera outbreaks were recorded in many countries in east Africa. In many African urban settlements, urban drift has outpaced the capacity of municipal authorities to provide civic works for sanitation and other health delivery services. The outbreak of cholera during recent floods in east Africa and Mozambique underscores the need for adequate sanitation. Moreover, the meningitis belt in drier parts of west and central Africa is expanding to the eastern region of the continent. Compounding these outbreaks are factors such as existing weak infrastructure, land-use change, and drug resistance by pathogens such as *Plasmodium falciparum* and *Vibrio cholerae* (World Health Organization [WHO] 1998a).

There is increasing evidence that climate change has a significant role in malaria epidemics in the African highlands (WHO 1998b). Although the principal causes were still a subject of debate in literature (Mouchet *et al.*, 1998), results from the "Mapping Malaria Risk in Africa" project (MARA/ARMA) show a possible expansion and contraction, depending on location, of climatically suitable areas for malaria by 2020, 2050 and 2080 (Thomas *et al.,* 2004). In Rwanda, malaria incidence increased by 33.7% in 1987, and 80% of this variation could be explained by rainfall and temperature (Freeman & Bradley, 1996 and Loevinsohn, 1994). Between 2050 and 2080, it is predicted that malaria transmission could change. For example, previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi could also experience moderate incursions of malaria by the 2050s, with conditions for transmission becoming highly suitable by the 2080s. Areas in Somalia and Angola which generally have low rates of malaria transmission could also become highly suitable by the same period. Among all scenarios, the highlands of Eastern Africa and areas of Southern Africa are likely to become more suitable for transmission (Hartmann *et al.,* 2002). It is also predicted that the malaria-carrying *Anopheles* female mosquito will spread to parts of Namibia and South Africa where it has not been found (UNEP, 2002a). These scenarios are alarming as the social and economic costs of malaria are huge and include considerable costs to individuals and households as well as at community and national levels (Holding & Snow, 2001; Malaney *et al.,* 2004 and Utzinger *et al.,* 2001).

In addition to the malaria epidemic, there other epidemics in East Africa have been associated largely with El Niño (WHO 1998a). In the 1997-8 El Nino occurrence, excessive flooding provided a conducive factor for cholera epidemics that were observed in Djibouti, Somalia, Kenya, Tanzania, and Mozambique—all lying along the Indian Ocean. Africa accounted for 80% of the total reported number of cholera cases globally in 1997 (WHO, 1998a). Other studies have echoed this assertion and expressed that flooding could facilitate breeding of malaria vectors and consequently malaria transmission in arid areas (Few *et al.*, 2004; McMichael *et al.*, 2006 and Warsame *et al.*, 1995).In the same respect, the Sahel region which has suffered from drought in the past 30 years has experienced a reduction in malaria transmission following the disappearance of suitable breeding habitats (Few *et al.*, 2004). Yet, there are risks of epidemics if flooding occurs (Faye *et al.*, 1995). Epidemics of meningitis that normally occur in the 'meningitis belt' in Africa usually start in the middle of the dry season and end a few months later with the onset of the rains (Angyo & Okpeh, 1997). This epidemic has been spreading from the original meningitis belt of Nigeria to Kenya, Uganda, Rwanda and Zambia. The fact that this disease has been limited to the semi-arid areas of Africa suggests that its transmission could be affected by warming and reduced precipitation (Angyo & Okpeh, 1997). El Niño has also been associated with increased episodes of diarrhoea and the RVF.

Impacts on Zimbabwe and Zambia

Both the IPCC and WHO have raised concern about potential adverse effects of climate change on human health. In Zimbabwe, investigations into the possible implications of climate change on human health have been rather limited. Similarly, research is also needed to fill the vast knowledge gaps relating to health issues associated with climate variability and change in Zambia (Chigwada 2004 and ZINC, 1998). However, reviews (WHO, ZINC, Chigwada) that have been conducted reveal the complex nature of the problem, where demographic changes, increase of malaria incidences, water-related health effects as well as changes in heat stress associated with temperature increases have been observed in these two countries.

In Zimbabwe, incidences of malaria usually reach a peak during the rainy season when temperatures are high and bodies of stagnant water are abundant. It is estimated that about one in every three people live in malaria risk areas. In 1996, the incidence of malaria was very high after heavy rains and high temperatures throughout the country. About 1.4 million clinical cases were reported. The estimated deaths of 6 000 represented a major cause of national mortality. In general, the risk is highest during the wet season and in low lying and warmer regions of the country. There are predictions that these increasing malarial trends are likely to become more pronounced as the climate changes. Already, 80% of variations in malarial incidences have been linked to changes in rainfall and temperature (Freeman & Bradley, 1996; Hulme & Sheard, 1999; Loevinsohn, 1994 and; WHO, 1998a). While by 2050 and continuing into 2080, for example, a large part of the western Sahel and much of southern central Africa is shown to be likely to become unsuitable for malaria transmission, there are other assessments which show that by 2100, changes in temperature and precipitation could alter the geographical distribution of malaria in Zimbabwe. Previously unsuitable areas of dense human population will become suitable for transmission. In particular, areas currently on the fringes of endemic malaria zones because of elevation would be most susceptible to infestation under future climate change. Harare, at an altitude of about 1470 m, is currently a city that is largely malaria-free, but is one of the large urban highland populations at risk from an expansion of the habitat of this disease-vector (Hartmann *et al.,* 2002 and Hulme & Sheard, 1999).

Similarly, in addition to being the largest cause of morbidity in Zambia, malaria is a major public health problem accounting for nearly 40% of all outpatient attendances at health facilities and the figure rises to 50% for children under five years. Moreover, four million clinical cases of malaria per year are reported in Zambia, culminating in approximately 50 000 deaths, including up to 20% maternal mortality (Chigwada 2004). Zambia is vulnerable to droughts, floods, extreme heat and shifts in rainy season length and almost all of these climate hazards will have a negative effect on health. Although a simple linear relationship between rainfall and malaria is unlikely to occur due to confounding factors such as temperature, socioeconomic conditions, population immunity levels, cultural habits and the impacts of existing interventions, a simple linear regression reveals that between 1998 and 2005 malaria increased as rainfall increased in Chadiza and Mazabuka Districts in the Eastern and Southern Provinces respectively. Studies from elsewhere in Zambia also found that malaria incidences in wet years were considerably higher than in dry years. Particularly notable are the reductions in malaria during the 2002 drought (Chigwada, 2004).

Other climate-change-associated diseases in Zimbabwe are cholera, dengue fever, yellow fever and general morbidity (ZINC, 1998). Climate change will also likely affect the distribution of tsetse flies, which carry sleeping sickness and the cattle disease, nagana, and the tick-borne livestock disease called East coast fever, or corridor disease. As with many impacts of climate change, preparing for change will be a key to successful adaptation (Hulme & Sheard, 1999). In the same respect, Zambia is already saddled with a huge disease burden with over eight million clinical cases of malaria, diarrhoea, respiratory infections and other communicable illnesses robbing the country of millions of productive hours each year. Human health will be affected by the rise in temperature, which will extend the habitats of vectors of diseases such as malaria. Access to potable water and sanitation is very low during droughts while floods increase the frequency of epidemics and enteric diseases (Chigwada, 2004).

Zambia's infant mortality rate is 112 per 1 000 live births. In 2003, the average life expectancy was 39 years and Zambia ranked 163 out of 175 in the Human Development Index (Chigwada 2004). The responses of diarrhoea and respiratory infections (that are not pneumonia) to rainfall are less clear. Nevertheless, in the case of diarrhoea, this may be due to the fact that in rural settings, droughts reduce water supplies, resulting in poor hygiene and less dilution of pathogens in water supplies, leading to more diarrhoea. In urban settings, however, more rainfall causes inadequate sanitation facilities to overflow or collapse, thus carrying more pathogens to humans. Dysentery appears to increase with drought conditions, and pneumonia correlates with rainfall with similar trends to those of malaria.

While morbidity due to HIV and AIDS is spread almost evenly over the three seasons, there are slight increases in morbidity seen during the cold dry season, perhaps because many infections in this season can hospitalize a person living with HIV and AIDS. The epidemic of meningitis has also been noted in Zambia and its transmission has been connected to warming and reduced precipitation (Angyo & Okpeh, 1997). Zambia's current disease burden is quite high, and achievement of the health-related Millennium Development Goal targets will require a drastic shift in health policy and investment.

2.3.2 IMPACT OF CLIMATE CHANGE ON WATER SOURCES

The international context

Water resources are inextricably linked with climate, so the prospect of global climate change has serious implications for water resources and development (Riebsame *et al.,* 1995). In Europe, although river discharge has also been affected by various other factors such as land-use change or the straightening of rivers for shipping, it is very likely that the current changes are largely due to precipitation changes (EEA, 2004). While river discharge decreased considerably in many southern European basins such as the rivers Jucar and Guadalquivir both in Spain, the Loire in France and the Adige in Italy, there have been large increases in discharge in Eastern Europe along the Danube (Winsor, 2001). However, in central Europe, only small changes in annual river discharge occurred in the Rhine and fresh water input to the Baltic Sea did not change between 1920 and 1990 (Winsor, 2001). Annual discharge is expected to decline strongly in southern and southeastern Europe, but increase in northern and northeastern Europe. Therefore, water availability will change over Europe in the coming decades. In the USA, irrigated agriculture's need for water is expected to decline by approximately 5-10% for 2030, and 30-40% for 2090 in the context of the two primary climate scenarios (the Hadley and Canadian), largely for 2 reasons; one is increased precipitation in some agricultural areas and the other is that faster development of crops due to higher temperatures results in a reduced growing period and thereby reducing water demand.

However, pumping out groundwater at a faster rate than it can be recharged is a major concern, especially in parts of the country that have no other supplies. In the Great Plains in Australia, for example, model projections indicate that increased drought conditions are likely and groundwater levels are already dropping in parts of important aquifers such as the Ogallala. In the same respect, Australia is currently facing extensive water resource challenges, particularly in the southwest, where current precipitation, run-off and stream flows have dropped to levels well below long-term averages. Water storage in reservoirs is also well below capacity throughout much of West and South Australia, Victoria and Queensland. Climate change is set to contribute to low precipitation in Australia and therefore exacerbate the reduction of water reserves. The current pressures placed on Australian water resources are indicative of their general high vulnerability to climatic change in this regard (Preston & Jones, 2006).

Impacts on Africa

The picture is worse for Africa as efforts to provide adequate water resources will confront several challenges such as population pressure; problems associated with land use, such as erosion/siltation; and possible ecological consequences of land-use change on the hydrological cycle. By 2000, about 300 million Africans risked living in a water-scarce[8] environment. Moreover, by 2025, the number of countries experiencing water stress will rise to 18, affecting 75-250 million and 350-600 million people in the 2020s and 2050s, respectively. A greater proportion of these will be in Africa (Arnell, 2004; World Bank, 1995). Essentially, climate change—especially changes in climate variability through droughts and flooding—will make addressing these problems more complex. The greatest impact will continue to be felt by the poor, who have the most limited access to water resources (Riebsame *et al.,* 1995).

Studies done in Africa show that the impact of changes in precipitation and enhanced evaporation could have profound effects in some lakes and reservoirs. About 63% of the total land in Africa lies within transboundary river basins. There are five major river basins—the Congo, Nile, Niger, Chad and Zambezi, which occupy about 42% of the geographical area and sustain more than 44% of the African population. Other shared basins in the continent are the Senegal, Gambia, Limpopo, Orange/Senqu and Cunene Basins. The Congo basin is shared by the highest number of countries (13), followed by the Niger and Nile basins (11 countries each) and the Zambezi and Chad basins (9 and 8 countries, respectively). Results from studies on the impacts of drought on reservoirs in Zimbabwe (Magadza, 1996) and Ghana (Graham, 1995) show that in the pale climate of Africa and in the present climate,

[8] Water scarcity refers to the change of run-off regimes and the change (mostly lowering) of the groundwater table (UNESCO, 2003a). Water stress on the other hand refers to a situation where water use exceeds water supply by 10% (UNEP, 2002a).

lakes and reservoirs respond to climate variability via pronounced changes in storage, leading to complete drying up in many cases.

In addition, the same studies also show that under the present climate regime several large lakes and wetlands show a delicate balance between inflow and outflow, such that evaporative increases of 40%, for example, could result in much reduced outflows. In the case of Lake Malawi, it has been reported that the lake had no outflow for more than a decade in the earlier part of this century (Calder *et al.*, 1995). Similarly, the effects of future climate change on Nile discharge would further increase uncertainties in Nile water planning and management, especially in Egypt. The rate of water utilization has already reached its maximum for Egypt, and climate change will exacerbate this vulnerability (Boko *et al.*, 2007).

Interruptions in hydroelectric power generations have also been significant in recent years as a result of severe droughts. The Volta hydroelectric dams in Ghana have been affected by multiple droughts in recent decades and this has as a result forced Ghana to reduce the generation of hydroelectricity, provoking a national debate about power supply (Graham, 1995). With regards to Lake Kariba, during dry years, generating capacity would decrease by as much as 50% (Arnell, 2004 and Urbiztondo, 1992).

There will likely be an increase in the number of people who could experience water stress by 2055 in Northern and Southern Africa and the greatest reduction in runoff by the year 2050 will be in the Southern Africa region (Arnell, 2006a & 2004; De Wit & Stankiewicz, 2006 and New, 2002). In contrast, more people in Eastern and Western Africa will likely experience a reduction rather than an increase in water stress (Arnell, 2006a). For Southern Africa, almost all countries except South Africa will probably experience a significant reduction in stream flow. Even for South Africa, the increases under the high emissions scenarios are modest at fewer than 10% (Strzepek & McCluskey, 2006). The Zambezi River has the worst scenario of decreased precipitation (about 15%), increased potential evaporative losses (about 15–25%), and diminished runoff (about 30–40%). Potential impacts of impoundment, land-use change, and climatic change on the Zambezi have been documented and it has been found that they can be substantial (Cambula, 1999 and Vorosmarty *et al.*, 2000). Impacts have also shown a decrease in surface and subsurface runoff of five streams in Mozambique, including the Zambezi under various climate change scenarios. For the Zambezi basin, simulated runoff under climate change is projected to decrease by about 40% or more.

However, some observers warn against over-interpretation of impact assessment results, owing to the limitations of some of the projections and models used (Agoumi 2003; Conway 2005; Legesse *et al.* 2003; Thornton *et al.* 2006). It is further suggested that these assessments of impacts on water resources, as already indicated, currently do not fully capture multiple future water uses and water stress and must be approached with caution (see, e.g., Agoumi 2003; Conway 2005). The suggestion herein is that there is need to have more detailed research on water hydrology, drainage and climate change. In essence, climate change should be considered among a range of other water governance issues (Conway 2005; Stern 2007).

Impacts on Zimbabwe and Zambia

In Zimbabwe, climate change is considered to have adverse impacts on water supply, water demand and on water conservation reliability. It is further projected that climate change will increase irrigation water requirements due to increased potential evapotranspiration for the doubling of CO_2 scenario (ZINC, 1998). Catchments will be water scarce as a result of challenges such as increase in demand due to population growth and allied uses, which will be compounded by climatic change.

The major form of water conservation in Zimbabwe is through the construction of dams. All urban centres and large-scale irrigation schemes depend on dams for water supply. The vulnerability of Zimbabwe to climate change is indicated largely by the impact of climate change on future water supply from dams. The amount of water that can be supplied by these dams with a reliability of 96% was estimated for the baseline and doubling of CO_2 scenarios. The costs of constructing reservoirs with such storage capacities were estimated to be extremely high. The analysis further shows that the yield of dams will decrease by about 30%-40%. If the same level of supply and reliability is desired, then there will be a need to either increase the storage of these dams or construct new ones. Increase in storage is not possible since all major dams are designed for their maximum yield (ZINC, 1998). With regards to Lake Kariba, generating capacity would decrease by as much as 50% during dry periods. And the maximum generating capacity would barely exceed 50% of installed capacity during wet years (Arnell, 2004 and Urbiztondo, 1992).

In addition, model simulations show annual rainfall for Zimbabwe declining by 5 – 20% of the 1961-90 average, by 2080 in all the country's major river basins. Agriculture has been identified as the sector most vulnerable to these climatic changes (ZINC, 1998). Estimations of water demand to year 2075 were based on population projections and average growth rates in water usage from 1950 to 1995. Rainfall-runoff simulation for the doubling of CO_2 scenario showed that a 15%-19% decrease in rainfall and a 7.5%-13% increase in potential evapotranspiration will result in a 50% decrease in runoff in the Gwayi, Odzi and Sebakwe catchments. Therefore, the climate change impact on runoff among the three representative catchments considered was a 50% decrease.

El Nino affects the precipitation in Zambia resulting in drought while La Nina is associated with floods. In the Kafue Basin there are already conflicts on water rights due to water demand for various uses including agriculture, hydroelectric-power generation, industry and domestic demand, which are considered to intensify with climate change. Zambia has a highly vascularised river system along with water bodies that cover as much at 6% of the total land area, which is dominated by the Zambezi River drainage system. Growing demands for water for hydroelectric power, urban agriculture and industrial consumption have led to conflicts over water rights in the Kafue Basin. A study by Arnell (2006b) states that the greatest reduction in run-off by 2050 in Africa will be in the Southern African region, suggesting that water use to resource ratio changes will put countries in the high water stress category. In addition, the shortfall in rainfall and the effect of increases in potential evaporation and the resultant reduction in run-off in the major river basins, including Zambia, could be as high as 40% (Chigwada, 2004).

In the same respect, low soil moisture and high evapotranspiration will promote desertification due to a reduction in vegetation cover. This will lead to soil erosion and sediment discharge that could cause siltation of reservoirs. Drought occurrences are also known to have caused a reduction in wildlife through deaths in the past besides a decline in tourism and reduction in water flows at the Victoria Falls (Chigwada, 2004).

2.3.3 IMPACT OF CLIMATE CHANGE ON THE ECONOMY

The international context

In Europe, 64% of all catastrophic events since 1980 are directly attributable to weather and climate extremes such as floods, storms and droughts/heat waves and 25% are attributable to landslides and avalanches, which are also caused by weather and climate (see difference between weather and climate in section 2.2.1. In addition, 79% of the economic losses and 82% of all deaths caused by catastrophic events result from these weather and climate related events (Wirtz, 2004). While non-climatic events, such as earthquakes remained stable, the annual average number of weather and climate related disastrous events in Europe doubled in the 1990s compared with the previous decade. This European trend is similar to the global trend. Annual global economic losses from catastrophic events increased from USD 4 billion a year in the 1950s to USD 40 billion per year in the 1990s (EEA, 2004). The insured portion of these losses rose from a negligible level up to USD 9.2 billion per year during the same period, with a significantly higher insured fraction in industrialised countries (IPCC, 2001a).

In Europe, economic losses caused by weather and climate related events have increased during the last 20 years from an annual average of less than USD 5 billion to about USD 11 billion. Austria, the Czech Republic, Germany, Slovakia and Hungary suffered economic losses of about USD 17.3 billion and insured losses of about USD 4.1 billion against the severe flooding in central Europe in August 2002 (EEA, 2004). In the US, a recent example of such impacts is the 1995-96 droughts in the agricultural regions of the southern Great Plains that resulted in about $5 billion in damages. The costs associated with floods and droughts include those incurred for building and managing infrastructure to avoid damages as well as costs associated with damages that are not avoided. These costs are in the billions of dollars and rising (NAST, 2000).

Impacts on Africa

Economic impacts of climate change are far reaching and studies focusing on climate change impacts on the economy in Africa are generally linked to the performance of agriculture (Calzadilla *et al.,* 2009 and De Wit, 2006). This is mainly because, for most Sub-Saharan African economies, agriculture is of great importance for supporting between 70% and 80% of employment, contributing an average of 30% of GDP and at least 40% of exports. What is disturbing is that agriculture in Sub-Saharan Africa is characterised by comparably low yields. While Asia experienced a rapid increase in food production and yields during the green revolution in the late 1970s and early 1980s, in Sub-Saharan Africa per capita food production and yields have stagnated (Calzadilla *et al.,* 2009). This has become a cause for concern because in Sub-Saharan Africa, 62% of the population live in rural areas and depend mainly on agriculture. Rural poverty accounts for 90% of the total poverty in the region and approximately 80% of the poor still depend on agriculture or farm labour for their livelihoods (FAO, 2005). National governments often struggle to provide food security during times of crisis (Ayalew, 1997). For national and international agencies, the cost of climatic hazards may result in a shift in expenditure from reducing vulnerability to simply coping with immediate threats (e.g., Dilley & Heyman, 1995). Therefore, development of irrigation and improvements in agricultural productivity are key variables not only for future economic development, poverty reduction and food security in Sub-Saharan Africa, but also for climate change adaptation (FAO, 2008).

Other economic impacts associated with climate change include those associated with drought and the curtailment of hydropower generation from the continent's lakes. A case in point is the curtailment of hydropower generation from Lake Kariba, as a result of the 1991–1992 drought, which was estimated to be USD102 million loss in GDP, USD36 million loss in export earnings, and loss of 3 000 jobs (Benson & Clay, 1998). In addition, climate change could lead to falls in the GDP of many countries in Africa. For example, climate change could lead to a fall of about 1.5% in South Africa's GDP by 2050 – a fall roughly to the total annual foreign direct investment in South Africa at present. In South Africa, a model developed by the Reserve Bank of South Africa indicated that the 1991-1992 droughts had a net negative effect of at least USD112.4 million on the current account of the balance of payments. Moreover, about 49 000 agricultural and 20 000 jobs in non-agricultural sectors were lost as a result of the 1991-1992 drought (Benson & Clay, 1998).

Floods in Mozambique in 2000 and in Kenya in 1997–1998 sparked major emergency relief as hundreds of people lost their lives and thousands were displaced from their homes (Brickett *et al.,* 1999; Ngecu & Mathu, 1999). The cost in Kenya alone was estimated at USD1 billion (Ngecu & Mathu, 1999). Furthermore, climate change and the resulting loss of biodiversity could do irreparable damage to the country's tourism industry, which is worth an estimated R100 billion per annum (about USD15 billion) (Benhin, 2006). According to 2004 statistics, the economic benefits of tourism in Africa which accounts for 3% of worldwide tourism may change with climate change (World Tourism Organization, 2005). The expected impacts of climate changes include reductions in the extent of grasslands and expansion of thorn savannas and dry forest, together with a general increase in the extent of desertification across the sub region. This will in turn affect the distribution of wildlife and some of the major national parks could suffer economic losses through reduced tourism potential (IPCC, 2001).

Under marked climate changes, African wildlife areas and parks may also attract fewer tourists. In the same respect, climate change could, for example, lead to a poleward shift of centres of tourist activity and a shift from lowland to highland tourism (Hamilton *et al.,* 2005). More than 90% of the global total of 80 species of world antelope and gazelle biodiversity is concentrated in Africa (Macdonald, 1987). Changes in climate of the magnitude predicted for the 21st century could alter the distribution range of antelope species (Hulme, 1996), yet biodiversity forms an important resource for African people. Uses are consumptive (food, fiber, fuel, shelter, medicinal and wildlife trade) and non-consumptive (ecosystem services and the economically important tourism industry). Despite the uncertainty of the science around impacts of climate change on the already outlined sectors, initial assessments show that several regions in Africa may be affected by different impacts of climate change which may further constrain development and the attainment of the MDGs in Africa (Boko *et al.,* 2007).

Impacts on Zimbabwe and Zambia

Future decreases in rainfall will have implications for the contribution made by Lake Kariba to the Zambian and Zimbabwean economies (Benson & Clay, 1998). Lake levels are crucial for energy generation at the Kariba Dam and also for the animals of the Kariba National Park sited along the banks of the reservoir. This is the case since tourism at Kariba makes a major contribution to Zimbabwe as a source of foreign exchange. The dry years of the mid-1980s led to a major fall in lakes level and subsequently a reduction in energy generation. Scenarios suggest further decreases in rainfall across the Zambezi basin, a trend that would undoubtedly lead to lower lake levels for Kariba. Furthermore, the 1991-92 drought which hit most of Southern Africa forced the Zimbabwe stock market to decline by 62%, causing the International Finance Corporation (IFC) to describe the country as the worst performer out of 54 world stock markets. The country's manufacturing sector declined by 9.3% in 1992. In the same respect, drought caused a 25% reduction in the volume of manufacturing output, and a 6% reduction in foreign currency receipts (UNEP, 2002a). In Zambia, economic impacts from curtailment of hydro-power generation from Lake Kariba on the Zambezi River as a result of the 1991-1992 droughts were estimated at USD102 million in GDP, USD36 million in lost export earnings and 3 000 job losses (Chigwada, 2004). Moreover, because Zambia's economy is agriculture based, drought is likely to have an adverse effect on the agriculture sector, resulting in lower economic growth.

2.3.4 IMPACT OF CLIMATE CHANGE ON AGRICULTURE

The international context

The yields per hectare of all cash crops have increased worldwide in the last 40 years and this trend can mainly be explained by technological success in breeding, pest and disease control, fertilization and mechanization (Hafner, 2003). Besides technical progress, agriculture in Europe is largely determined by the CAP and is also affected by the cut in and decoupling of subsidies for agricultural products since the European Union (EU) agricultural reform of 1993, which has already led to a reduction in the area under cultivation. Although in Europe, the attribution of climate change to crop yield trends is likely to be small, weather extremes have adversely influenced yield results in the past decades (EEA, 2004). A case in point is the heat wave in 2003 in which high temperatures and a long period with low or no precipitation led to droughts in large parts of Europe. Consequently, a drop in crop yields was the strongest negative deviation from the long-term trend in Europe in the last 43 years (FAO, 2004). While most countries, including Greece, Portugal, France, Italy and Austria, suffered from yield drops of up to 30%, some countries such as Denmark and Finland profited from the higher temperatures and lower rainfall. One positive effect of climate change that is already apparent is the earlier sowing date for certain crops due to an earlier start and longer duration of the vegetation period (EEA, 2004).

Model simulations suggest that the net effects of the climate scenarios studied on the agricultural segment of the USA's economy over the 21st century are generally positive. The exceptions are simulations under the Canadian scenario in the 2030 time period, particularly in the absence of adaptation. Crops showing generally positive results include cotton, corn for grain and silage, soybeans, sorghum, barley, sugar beet and citrus fruits. Pastures also show positive results (NAST, 2000). Most commercial crops in the USA, including wheat, rice, barley, oats, potatoes, and most vegetable crops, tend to respond favourably to increased CO_2, with a doubling of atmospheric CO_2 concentration leading to yield increases in the range of 15- 20%. In situations where crop yields are severely limited by factors such as nutrient availability, an enduring CO_2 fertilization effect is very likely to be of only minor importance.

The length of the growing season is very sensitive to climate. An increase in the length of the growing season by about 10 days from 1962 to 1995 has been noted and this has been consistent with an increase of about 12% in the "greenness" of vegetation (Menzel & Fabian, 1999 and Zhou *et al.,* 2001). Greener biomass (needles and leaves) is an indicator for an increase in plant growth. This is because the extension of the growing season in both spring and autumn, mostly coupled with higher temperatures during the growing period, appears to enhance productivity and increase species diversity. Regional trends can vary from the European averages; for example, the growing season has shortened in the Balkan region (Menzel & Fabian, 1999).

However, an increase in cases of tick-borne diseases per year has been observed since the 1980s in the Baltic countries, namely Sweden, Finland, Poland, Latvia, Estonia and Lithuania as well as central European countries such as Switzerland, Germany, Czech Republic and Slovakia. These diseases have been noted to reduce livestock herds in these countries as farmers struggle to maintain their large heads. This affects these farmers as they rely significantly on livestock for protein (Jaenson *et al.,* 1994). In Sweden, ticks expanded their northern distribution extensively between 1980 and 1995 (Jaenson *et al.,* 1994 and Lindgren *et al.,* 2000). These have generally been attributed to temperature increases over the past decades. During this period, northern areas with newly established tick populations had less severe winters and more summer days. The density of tick populations has increased in endemic areas (permanently populated by ticks) in central Sweden during the same period (Tälleklint & Jeanson, 1998), due to milder winters, earlier springs and prolonged autumns (Lindgren *et al,.* 2000).

Impacts on Africa

Of importance is the concern that impacts associated with climate change may be particularly severe for many African countries (IPCC, 2001). While it may be argued that African farmers have adapted to climate variations in the past, future climate change may force large regions of marginal agriculture out of production in Africa (Mendelsohn *et al.,* 2000a & 2000b). Impacts of changes in climate on agricultural activities both physical and economic have been shown to be significant for low input farming systems, such as subsistence farming in developing countries in sub-Saharan Africa that are located in marginal areas and have the least capacity to adapt to changing climatic conditions (Kates, 2000; McGuigan *et al.,* 2002; Reilly & Schimmelpfennig, 1999 and Rosenzweig & Parry, 1994). Africa is already a continent under pressure from climate stresses and is highly vulnerable to their impacts. Estimates indicate that one third of African people already live in drought-prone areas and 220 million are exposed to drought each year (UNFCCC, 2007). IPCC predicts that by 2020, yields from rainfed agriculture in some countries could be halved and agricultural production and access to food may be severely compromised. Up to 250 million Africans could face water shortages (Vermuelen *et al.,* 2008).

Agriculture is a vital source of food and the prevailing way of life in Africa. An average of 70% of the population lives by farming, and 40% of all exports are earned from agricultural products (WRI, 1996). In this regard, agricultural and economic growth must rise in order to realize basic development goals. Today, only a few countries achieve this rate of growth. A major challenge facing Africa is to increase agricultural production and achieve sustainable economic growth as both are essential to improving food security. Food security in Africa already is affected by extreme climate events, particularly droughts and floods (Kadomura, 1994 and Scoones *et al.,* 1996). The ENSO floods in 1998 in East Africa resulted in human suffering and deaths, as well as extensive damage to infrastructure and crops in Kenya (Magadza, 2000). It has been further estimated that global warming is likely to alter production of rice, wheat, corn, beans, and potatoes—staples for millions of people and major food crops in Africa. Staple crops such as wheat and corn that are associated with subtropical latitudes may suffer a drop in yield as a result of increased temperature, and wheat and rice may disappear because of higher temperatures in the tropics by 2080. Around the same time, a significant decrease in suitable rain-fed land extent and production potential for cereals is estimated under climate change (Odingo, 1990; Pimentel, 1993 and Stige *et al.,* 2006).

Droughts in the Southern Africa region in 1991–1992 and 1997–1998 affected livelihoods and economies and heightened renewed interest in the impacts of climatic hazards (e.g., Campbell, 1999 and Kadomura, 1994). Adverse effects of climate change on agriculture would have severe implications not only for South Africa, but also for the Southern African region because South Africa is the region's major source of food. For example, 50% of the maize (the main staple) in the SADC region is produced in South Africa. Adverse effects in South Africa could, therefore, destabilize the whole region (Benhin, 2006). For example, the impacts of the 1991–1992 droughts in Zimbabwe are estimated to have been 9% of GDP (Benson & Clay, 1998). Moreover, Southern Africa would be likely to experience notable reductions in maize production under possible increased ENSO conditions.

Even the effect of climate change upon livestock production has received attention (see, Hahn 1990; Hahn *et al.* 1992). Domestic livestock play a central role in many African cultures and this role goes beyond the production of meat. Their value is based on the full set of services they supply (milk, meat, blood, hides and draught power), their asset value as a form of savings, and their cultural symbolism. It would be difficult and damaging for farmers to abandon livestock rearing and cultures of pastoralism in the event that it becomes climatically, environmentally, or economically unviable. There is a real possibility that climate change will have a negative impact on pastoral livelihoods as there is evidence that in the higher altitude and higher latitude regions of Africa, livestock such as sheep are currently exposed to winter temperatures below their optimum. Mortality often results when cold periods coincide with wet periods, if the animals have not been herded to shelter.

Simulations of changes in the distribution of tsetse fly (*Glossina spp.*) indicate that with warming it could extend its range southward in Zimbabwe and Mozambique, westward into Angola, and northeast into Tanzania, although in all these simulations there were substantial reductions in the prevalence of tsetse in some current areas of distribution. The tick *Riphicephalus appendiculatus* was predicted to decrease its range in southern and eastern Africa and increase its range in the central and western part of southern Africa (Hulme, 1996). In addition, while, increased precipitation of 14% would be likely to reduce the income of small livestock farms by 10% (–USD 0.6 billion), mostly due to a reduction in the number of animals kept, a reduction in precipitation would be likely to reduce the income of large livestock farms by about 9% (–USD5 billion), due to a reduction both in stock numbers and in net revenue per animal (Seo & Mendelsohn, 2006a & 2006b).

An outbreak of RVF in Somalia and Northern Kenya killed as much as 80% of the livestock and affected their owners and many cases were also reported in Tanzania. This followed the 1997-1998 El Nino events and in Kenya the RVF has been linked to flooding (WHO, 1998b). It can, therefore, be expected that increased precipitation as a consequence of climate change could increase the risk of infections in livestock and people (Baylis & Githeko, 2006). On the other hand, heat stress and drought are likely to have further negative impacts on animal health and production of dairy products, as already observed in the USA (St-Pierre *et al.*, 2003 and Warren *et al.*, 2006). For Africa, it has been predicted that such impacts may further constrain development and the attainment of the MDGs. There is the possibility that adaptation could reduce these negative effects (Benhin, 2006). Adaptive capacity and adaptation thus emerge as critical areas for consideration on the continent and in southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures (Boko *et al.*, 2007).

Impacts on Zimbabwe and Zambia

There has been extensive research on the impacts of climate change, but little has been done on the impacts on agriculture in Zimbabwe (Mano & Nhemachena, 2006). This provides a context for this study to investigate the impacts of climate change on agriculture in Zimbabwe, considering that agriculture remains the backbone of the country's economy. The agricultural sector contributes about 17% to the country's GDP (FAO, 2005). Agriculture is also an important source of raw materials, providing about 60% of raw materials for the manufacturing sector in the country (Bautista *et al.,* 2002 and Poulton *et al.,* 2002). For instance, drought years that are depicted by negative rainfall deviation correspond with the declining and low growth rate in GDP contribution from the agricultural sector, implying that rainfall patterns have a significant effect on this contribution over the years. Notable examples are the growth rates in the early 1970s, early 1980s and the 1992 drought. More droughts were witnessed in the seasons 2002/3 and 2007/2008. During these drought years the temperature increased and the rainfall was very low, and this had a significant effect on agricultural performance and hence the growth rate of GDP contribution from the sector (Mano & Nhemachena, 2006).

Most crops are highly sensitive to climate and ecosystems will shift over space in response to climate change. For instance, research done in various countries in Southern Africa has demonstrated that a 2ºC rise in ambient temperature and a rise of mean temperature by 4ºC have significantly lowered yields (Agoumi, 2003). Potential effects of climate change on corn, using a GCM and the dynamic crop growth model CERES-maize in Zimbabwe, showed that maize production was expected to significantly decrease by approximately 11–17%, under conditions of both irrigation and non-irrigation (Agoumi, 2003; Magadza, 1994; Makadho, 1996; Mano & Nhemachena, 2006; Muchena, 1994 and Stige *et al.*, 2006). In this regard, it is suggested that major changes in farming systems can compensate for some yield decreases under climate change, but additional fertilizer, seed supplies, and irrigation will involve an extra cost. In addition, results of analysis of potential impacts using dynamic simulation and geographic databases reaffirm the dependence of production and crop yield on intra-seasonal and inter-annual variation of rainfall for South Africa and the Southern Africa region (see Hulme 1996; Schulze *et al.* 1995; Schulze 2000).

A study done to see how agricultural production would respond to climate change in Zimbabwe indicates that a 2.5°C increase in temperature would decrease net farm revenues by USD 0.4 billion. A 5°C increase in temperature would decrease net revenues across all farms, dryland farms and farms with irrigation by USD0.4 billion, USD0.5 billion and USD0.003 billion respectively (Mano & Nhemachena, 2006). Moreover, a 7% and a 14% decrease in precipitation would result in a decrease in net farm revenue by USD0.3 billion for all farms (Mano & Nhemachena, 2006). Irrigated farms are, therefore, portrayed to be more resilient than farms under rain-fed agriculture. Even though irrigation will boost maize production in all areas, the yields are lower under climate change conditions than under normal climate. The reduction in mean seasonal precipitation under climate change conditions implies that the water available for irrigation purposes would also be affected accordingly and this will reduce the effectiveness of irrigation as a strategy to combat the effects of climate change. More importantly, broad-scale shifts in agricultural capability due to climate change would affect rural livelihood and the national economy. Subsequently, all vulnerable groups are threatened by climate change through the ripple effects that diminish the resource base and increase the possibility of resource conflicts and tensions between the agricultural and industrial sectors (Matarira *et al.,* 1995).

Zimbabwe has witnessed discernible shifts in agro-ecological[9] regions. With higher temperatures projected to shorten the growing season of crops by 2 to 35 days, one of the obvious consequences is reduced crop yields as well as decreased livestock productivity. In the study done by Matarira *et al.* (1995) maize production at all stations is more consistent under normal climate than under climate change conditions. Climate change introduces greater variability in maize yields, thus making maize production a more risky agricultural activity. This will impact negatively on the socio-economic lives of the people in general and food security in particular. For instance in Masvingo, which represents Region IV in this study, there is a strong likelihood that climate change will make the Region a non-maize producing area. Implications herein are that Region IV, which represents 42% of communal areas, will not adequately supply its population with the staple food crop. This is contrary to the MDG 1, which happens to be central and related to all the others and spells out the need to eradicate extreme poverty and hunger.

Because Zambia's economy is agriculture-based, drought is likely to have an adverse effect on food security, resulting in lower economic growth. It is anticipated that there will be reduced precipitation; high temperatures and evapotranspiration during droughts, which will affect the staple food production. Similarly, floods and droughts will affect agricultural production, which can be worsened by the occurrence of pests. On the other hand, removal of vegetation cover through fires or overgrazing increases the risk of soil erosion during heavy downpours. This, too, leads to decreased agricultural productivity (Chigwada, 2004). For example, excessive rain in 2001 and dry spells during the 2001/02 growing season led to a major shortfall in maize production, a decrease of 42% compared with the average yearly production. Compounding the plight of agriculture in Zambia is the incidence of HIV/AIDS due to unavailability of labour as the agricultural production among smallholder farmers is labour-intensive (Chigwada, 2004).

Agriculture is becoming an increasingly important sector in the Zambian economy since the mineral sector, which was the backbone of the economy from post-independence times (1964) till the late 1980s, has declined. The agriculture sector generates about 18% to 20% of the country's GDP, provides a livelihood for more than 60% of the population and employs about two-thirds of the labour force (Jain, 2006). Agriculture in Zambia depends on rainfall to a very large extent. In this regard, the negative impacts of extreme climate events which are believed to be manifestations of long-term climate change have affected crop production in the country since the 1990s (Jain, 2006). The last two decades have seen Zambia

[9] Zimbabwe is divided into five agro-ecological regions in a continuum, with region one receiving the highest rainfall and region five the least.

experiencing some of its worst droughts and floods (also experienced in most of SADC), notably, the droughts of 1991/92, 1994/95 and 1997/98 worsened the quality of life for vulnerable groups such as subsistence farmers (Muchinda, 2001). For instance, the yield during the severe drought of 1991/92 was less than half that of 1990/91. In Zambia in the seasons 1972/73, 1979/80, 1981/82, 1983/84, 1986/87, 1993/94 and 1994/95, significant shortfalls in maize yields were also recorded and these seasons were characterised as having below normal rainfall by the Zambian meteorological department. Essentially, drought has been the biggest shock to food security in the country during the last two decades (MoA, 2000 and Muchinda, 2001).

In addition, the impact of extreme climate events has been felt in substantial loss of livestock and fertile soil. Low productivity in the agricultural sector has contributed to a low GDP. In a study done in Zambia by Jain (2006) it was found that there may be a negative effect if temperature rises at the beginning of the cropping season when plants are germinating as evidenced by the marginal net revenue per hectare USD322.628 for an increase of 1°C in the mean temperature in November and December. In addition, although the marginal net revenue per hectare of USD315.70 for an increase of 1°C in the mean temperature of January and February indicates that if the temperature rises during the growing stage of the plant, this may have a positive effect on the crop, a decrease of about 20% in the precipitation for this period can reduce the net revenue by about USD334.67 (Jain 2006). Given these findings, agricultural production in Zambia is subject to the uncertainties of extreme climate events, which are indicative of an increasing mean temperature and reduction in total seasonal rain on a long-term time scale.

2.4 CONCLUSION

This chapter has outlined the importance of understanding the trajectories of climate change, going back to the 1800s when scientists began to realise the contribution of green house gases to climate change to recent work that was conducted over nearly two decades to cement the conclusion that global warming and the subsequent climate changes are largely due to human activities. This chapter has also focused on the debates surrounding causes of climate change which are centred on whether climate change is induced by anthropogenic activities or simply due to natural variability. While there is no consensus on the causes of climate change, the majority of the world's scientists who study this topic conclude that expected climate change would differ from previous climate change because of human activities. It is further demonstrated in this literature review that it is the developing nations that are hard hit by climate change more than the developed nations. Therefore, this ushers in the element of climate change adaptation. There is the possibility that adaptation could reduce these negative effects. Adaptation thus emerges as a critical area for consideration on the continent in general and in Southern Africa in particular. In this regard, Chapter 3 reviews literature on human vulnerability and adaptation to environmental and climate changes.

CHAPTER 3: HUMAN VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

3.1 INTRODUCTION

This chapter, which is divided into three parts, presents the context of human vulnerability and adaptation to climate change. Part one outlines the key concepts in the context of this chapter, namely, 'risk and vulnerability', 'coping strategies', 'adaptive strategies' and 'adaptive capacity'. Part two gives a historical overview of adaptation to environmental and climate change. Part three of this chapter focuses on vulnerability and adaptation to environmental change. This part is divided into two sections. Section one gives a summary of literature on environmental change while section two presents case studies of vulnerability and adaptation to these changes. In section one, literature is reviewed on environmental hazards, human vulnerability to these hazards and disaster reduction and adaptation. Section two presents case studies of vulnerability to four environmental changes in Africa, namely, land degradation, climate change, deforestation and cyclones.

3.2 KEY CONCEPTS ON CLIMATE CHANGE ADAPTATION

3.2.1 'RISK' AND 'VULNERABILITY'

Many references have been made to the word vulnerability as if it were the same phenomenon as risk. There has been fuzziness in distinguishing between 'risk' and 'vulnerability' (Bogardi, 2004). It is important to emphasise that these are two different concepts. Despite efforts by social scientists undertaken since the mid 20th century (Kates, 1971; White 1974), the issue of risk assessment seen from the perspective of disaster risk has been treated fairly recently. Initially, it was conceptualised in the natural sciences with studies regarding geodynamic, hydro meteorological and technological phenomena such as earthquakes, volcanic eruptions, mudslides, flooding and industrial accidents (Cardona, 2003). Although this emphasis still remains, particularly in highly developed countries, scholars in developing countries have realised the importance of incorporating vulnerability and have started linking social aspects with vulnerability. There is a general consensus that there is a need for greater study of individual and collective perceptions of risk in order to find effective means to achieve a reduction in the impact of disasters worldwide

. Since risk is generally defined as the product of the hazard probability and its consequences, risk can be viewed as a function of the hazard event and the vulnerability of the elements exposed.

Risk can be conceptualised either as connected with probabilities or certainties about life-long negative consequences or handicaps. When risk is viewed as a function of a hazardous event, it is understood to be connected with probabilities. On the one hand, risk or adversity in social psychology comprises genetic, biological, psychological, environmental or socio-economic factors that are associated with an increased probability of maladjustment such as divorce, family violence, civic unrest and war. On the other hand, environmental, natural and socio-economic risks are systemically connected and these risks are individual actors within a specific community (Sapountzaki, 2007). Although these risks are individual actors in society, it would be naïve to disregard the fact that individual risk trade-offs that result in prioritization of socio-economic risks or disregard of environmental ones bear detrimental effects to the natural and/or man-made environment (Sapountzaki, 2007).

Climate-related risks, in particular extreme events, play an important role in the climate change debate. Management of these climate related risks can be either through disaster preparedness or climate change adaptation and this can create positive synergies and opportunities for progress in the climate negotiations (United Nations University-Institute for Environment and Human Security [UNU-EHS] 2008). Furthermore, resilience to climate risks can be built by insurance mechanisms which can in turn reduce the vulnerability of people to climate risks. The importance of moving from reactive *ex post* (coping) disaster management approaches to more *ex ante* (adaptation) pre-disaster activities is emphasised (UNU-EHS, 2008).

While there is a fair consensus regarding the terms "hazard"-the occurrence of an extreme event with an estimated (low) frequency and "risk"-associating the occurrence probability of the extreme event (hazard) with the economic and financial losses it would imply, there is much uncertainty about what the term "vulnerability" covers (Kron, 2003 and Plate, 2002a & 2002b).

While in the 1970s and early 1980s, vulnerability was often associated with physical fragility (e.g. the likelihood of a building to collapse due to the impact of an earthquake), today the concepts of vulnerability go far beyond the likelihood of collapsed physical structures (see Plate 2004). The concept of vulnerability has been continuously widened and broadened towards a more comprehensive approach encompassing susceptibility, exposure, coping capacity and adaptive capacity, as well as different thematic areas, such as physical, social, economic, environmental and institutional vulnerability (Kron 2003). Although substantive research has been undertaken on vulnerability to climate change, it appears that there is uncertainty on what the term 'vulnerability' covers (Bogardi, 2004; Kron, 2003 and Plate, 2002a & 2002b). This uncertainty and fuzziness of the concept of vulnerability implies that there is need for further research to consider features and nature of vulnerability in specific contexts. Keeping in mind the ongoing climatic, environmental, but also socio-economic and political changes in various environments, an additional important research question is to clarify, how (social) vulnerability is affected by these trends and fluctuations (Bogardi, 2004). This puts into perspective the focus for this study regarding vulnerability. It is important in this study to understand whether farmers' vulnerability influences their adaptation to climate changes.

Vulnerability is considered to be the "ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to, any external stress placed on their livelihoods and wellbeing" (Kelly & Adger, 2000:22). Examples of vulnerability include a "high degree of exposure to risk, shocks and stress; and proneness to food insecurity" (Ellis, 2000:35) and a "function of exposure, sensitivity and adaptability" (McCarthy, 2001:61). Vulnerability varies widely across people, whether in the same place or not. It is, therefore, imperative to understand it both spatially and socially in the given sites. Vulnerability is often used as a synonym for poverty. However, poverty and vulnerability are not synonymous (Tol *et al.*, 2004). Extreme climate events can impact the wealthy and poor alike, particularly in high-risk environments (Liverman, 1994 and O'Brien & Leichenko, 2000). Although poor people are usually the most vulnerable, not all vulnerable people are poor. For example, a poor household may not be vulnerable to economic shocks such as collapse of agricultural prices, if almost all of its food is produced for household consumption or shared between households. Furthermore, a better-off household may be vulnerable to climate change if, for instance, it does not have sufficient access to weather information. Although one could argue that the wealthy are more resilient to recovery through mechanisms such as insurance, it is likely that premiums in high-risk areas will become increasingly difficult to obtain if climate variability increases with climate change (Kerry *et al.* 1999 and Stix 1996).

In the context of multiple stresses, vulnerability includes: long-term trends, such as demographic trends, e.g. migration, or changes in the natural resource base; recurring seasonal changes such as prices, production or employment opportunities, trade liberalization and short-term shocks such as illness or disease, natural disaster or conflict (Gandure *et al.*, 2007). Negative impacts of climate change are likely to hit the poorest people in the poorest countries hardest. Essentially, the poor are the most vulnerable to climate change. The geography of many developing countries leaves them especially vulnerable to climate change (see Stern, 2007). Those developing countries that continue to experience rapid growth will be much better placed to deal with the consequences of climate change. Other areas, predominantly low-income countries, where growth is stagnating may find that their vulnerability increases (Stern, 2007). Moreover, since women form a disproportionate share of the poor in developing countries and communities that are highly dependent on local natural resources, women are likely to be disproportionately vulnerable to the effects of climate change. Because of gender differences in property rights, access to information and in cultural, social and economic roles, the effects of climate change are likely to affect men and women differently (Kyomuhendo & Muhanguzi, 2008 and Nelson & Sthathers, 2009).

There are various approaches to vulnerability assessments, which include using poverty as a proxy indicator of vulnerability to food insecurity by identifying the number and location of socioeconomic groups judged to be vulnerable and carrying out surveys to collect information directly related to vulnerability. Other approaches include incorporating the notion of coping strategies and levels of entitlements. Conducting a rapid rural appraisal and making use of individuals with expertise related to the issues addressed, and with extensive knowledge of conditions throughout the country have also been cited as other ways of assessing vulnerability (WFP, 1996). This study makes use of one of these ways to assess vulnerability to climate changes by farmers in Zambia and Zimbabwe by using surveys to collect information directly related to levels of entitlements and coping strategies.

3.2.2 COPING STRATEGIES

Coping strategies can be defined strictly as short-term measures or as "the bundle of producer responses to declining food availability and entitlements in abnormal seasons or years" (Davies, 1996:59). Available literature posits that coping begins when a household is forced to mobilize resources in order to respond to crises (Adams *et al.,* 1998). In the same context, Ellis (1998) defines coping strategies as actions that are invoked following a decline in "normal" sources of food, and which are regarded as involuntary responses to disaster or unanticipated failure in major sources of survival. Coping strategies are also defined as strategies that have evolved over time through peoples' long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the season as it unfolds (Cooper *et al,*. 2007 and Mortimer & Manvel, 2006). This idea is supported by Reardon *et al.* (1988) who demonstrated that populations living in more marginal environments are often more equipped to cope with periods of food stress than those accustomed to more secure conditions than they may have learnt to adapt to.

However, Young & Jaspars (1995) argue that the coping strategies used in communities which face an annual food gap (as in southwest Niger) make it difficult to determine the true intention of a strategy, as over time they become more integrated into annual activities and discerning their meaning and disentangling them from adaptation becomes difficult. This may also be the case as coping strategies are not only used in times of stress or when disaster strikes. Instead, they are used all the time, but assume greater importance in difficult times

(Campbell, 1990). Given this cautionary statement by Young & Jaspars (1995), it is imperative for this study to identify whether existing coping strategies employed by the target farmers are exclusive to climate shocks or whether they have become part of their adaptation system.

In this respect, coping strategies have in some literature been classified as 'long-term" and "short-term". Long-term strategies involve risk minimizing and no commitment of resources. These have also been termed insurance strategies that have low risk, but high return (Corbett, 1998). In addition, these strategies enable the households to sustain themselves for a relatively longer period of time. Coping strategies classified as short-term range from getting into a crisis, coping within a crisis to a complete failure. Less resilient strategies are used and this usually calls for the disposal of assets. They also tend to threaten future livelihood and are considered to have both low risk and low return and high risk and low return (Davies, 1996). If these coping strategies are 'erosive" and used over time, they may trap farmers in cycles of food insecurity (De Waal, 2003). In addition, these erosive measures are desperate strategies that farmers take in order to cope in the immediate term and cannot sustain the household for long. Examples of coping strategies that have been cited by authors who distinguish coping from adaptation include consuming crops before maturity due to hunger, borrowing money or food and disposal of key productive assets among others (Phillips, 2007).

The fact that farmers are sometimes able to cope in stressful periods indicates that it is important to identify local knowledge which enables them to construct livelihood in response to constraints and opportunities and that they have the ability to cope with changing conditions over time. Utilizing a context specific framework for evaluating coping strategies can lead to better understanding the concept as these coping strategies vary by context. For instance, it has been observed in Zimbabwe that most farmers rely on their own production and on the market to fulfil their food needs. When the same farmers experience a production shock, they become even more dependant on money-based transactions (Gandure & Marongwe, 2006).

3.2.3 ADAPTIVE STRATEGIES

Davies (1993) distinguishes between "coping" and "adaptation" activities. She defines "adapting" as a "means of permanent change in the ways in which food is acquired, irrespective of the year in question" (Davies, 1996:60). Adaptation is the ability to respond and adjust to actual or potential impacts of changing climate conditions in ways that moderates harm or takes advantage of positive opportunities. It reflects positive actions to change the frequency and/or intensity of impacts, as opposed to coping strategies that are responses to impacts once they occur (Adger *et al.*, 2003; IPCC, 2001:982 and Reid & Vogel, 2006). Other scholars add that the responses are not exclusively a response to climate, actual or expected climatic stimuli, but other effects from non-climatic stimuli (Smit *et al.,* 2001). This assertion compels this study to examine adaptation in climatic change as distinct from other non-climatic stimuli.

Essentially, adaptive strategies are long-term and involve a longer time frame and some learning of the strategy before or after a climate related occurrence. Adaptation can be reactive (after impact takes place) or anticipatory (before impact takes place), and can, therefore, be carried out in response to or in anticipation of changes within existing situations (IPCC, 1995 and Reid & Vogel, 2006). In the proactive scenario, this is where systems adjust before the initial impacts take place. Change is introduced in response to the onset of impacts that will re-occur and reflect a structural change of state of the system in cases where adaptation is reactive (Adger *et al.*, 2007). Moreover, numerous studies show that adaptation is not new as farmers and communities have always been at risk from both climatic and non-climatic factors. In this regard, they have continued to find ways of adapting. These studies further show that some of these adaptation strategies have been successful and others have not (Adger *et al.,* 2007; Benhin, 2006; Boko *et al.,* 2007, Bryceson, 2006; Cooper *et al.,* 2006; Phillips, 2007 and Wehbe *et al.,* 2006). Examples of adaptation mechanisms that have been observed by these studies and assessments of impacts and adaptations of climate change include crop diversification, irrigation, construction of water reservoirs, accumulating food surpluses and use of drought resistant varieties, among others. There is an indication that in most cases, these strategies have been adopted in response to multiple sources of risk and rarely to climate risk alone.

Although studies have been done in many locations on adaptation strategies, there is still need for further studies in order to understand the needs and options that farmers have for building their adaptive capacity. This is the case as adaptation varies by context. Pottier (1993) argues that periodic or chronic food stress does not cause all members of a population to be similarly or equally affected. For instance, although dryland areas may share common characteristics and the population may be exposed to similar shocks, household and individual responses differ. Adaptation is largely influenced by the nature of the hazard in question. In other words, farmers may be able to adapt to inconsistent rains, but not to droughts depending on their capacity at that moment. This is referred to as "specific adaptation". On the other hand, when they can adapt to a range of hazards then this is referred to as "generic adaptive capacity" (Adger *et al.,* 2003 and Reid & Vogel, 2006). In this respect, this study examines the differences and similarities in the current adaptation strategies that are being employed by farmers in the study areas.

The distinction in the characteristics of coping and adaptive strategies, based on a number of variables, is summarised in Table 1. The differences are mainly based on the time dimension, which is, coping being short-term and adapting being long-term. Moreover, in terms of efficiency, coping strategies are considered to be efficient in the short-term and adaptive strategies in the long-term. Also of importance is the element of flexibility of strategies in which coping strategies are considered to be acting within the rule system and adaptive strategies change the rule systems (IISD, 1993).

Table 1: Characteristics of coping and adaptive mechanisms

Characteristics	Coping mechanisms	Adaptive strategies
Time dimension	Short-term	Long-term
Cause	Locally or externally induced	Locally or externally induced
Space	Acting within the prevailing rule system	Change the rule systems, or moral economy
Efficiency	Efficient in short-terms	Efficient in long-terms
Nature	Socio-economic in nature	Socio-economic and environmentally responsive. Interactive and dynamic
Resilience	Reversible in short-term	Sustainable. Difficult resilience

Source: IISD (1993)

3.2.4 ADAPTIVE CAPACITY

The degree to which adjustments are possible in practices or structures of systems to projected or actual changes of climate is referred to as adaptive capacity and this is largely influenced by the resilience within the system or community (UNFCCC, 2002 and Reid & Vogel, 2006). It is also considered to be the ability of farmers to respond successfully and make adjustments to climate variability and change by drawing on resources and technologies (Brooks & Adger, 2005). In addition, adaptive capacity is the ability to ameliorate the negative consequences of climate change and take advantage of the positive changes. Adaptive capacity is thought to be determined by technological ability, economic resources and their distribution, and human, political and social capital (Tol *et al.,* 2004). Farmers' capacities to respond to stress and uncertainty depend on ownership or access to a wide variety of resources such as landholding size and soil quality, machinery and equipment, credit and insurance, education and age, technical assistance and information, social networking, and public support programs (Blaikie *et al.,* 1987; Ellis, 2000 and Scoones, 1998).

There are a host of factors that influence the adaptive capacity of farmers in the face of a wide range of hazards. These determinants have been classified by scholars into two categories, namely, generic and specific. While education, income and health have been considered to be generic, specific determinants to particular impacts such as droughts and floods may relate to institutions, knowledge and technology (Brooks *et al.,* 2005; Downing, 2003; Tol & Yohe, 2007 and Yohe *et al.,* 2007). Other determinants of adaptive capacity include demographic factors, dependence on agriculture and natural ecosystems and resources, poverty and inequality (Adger *et al.,* 2003; Reid & Vogel, 2006). For example, low adaptive capacity of Africa is due in large part to the extreme poverty of many Africans.

Developing countries are the most vulnerable to climate change impacts because they have fewer resources to adapt: socially, technologically and financially (UN, 2007 and UNFCCC, 2007). In this regard, this study is compelled to analyse factors that influence small holder farmers' adaptive capacity in Zimbabwe and Zambia.

Numerous studies have pinpointed that institutions and their effective functioning play a critical role in successful adaptation (Adger *et al.,* 2007 and Reid & Vogel, 2006). It is, therefore, important to understand the design and functioning of such institutions which include both formal and informal institutions. For instance, Reid & Vogel (2006) established that these institutions may be conceptualised as farmers and local community groups, public and government institutions and local organizations. Therefore, links to these institutions also shape the adaptive capacity of a household. Also related to these institutions are the enhanced communication of climate-related information and the development of social networks which can assist farmers to know times when there is higher probability of success in use of adaptation strategies (NOAA, 1999 and Stern & Easterling, 1999). There is need to strengthen institutions and facilities that disseminate weather information for the benefit of the farmers. This is imperative as there is evidence that seasonal forecasting in Africa has not reached optimum levels (Thiaw *et al.,* 1999), implying that seasonal forecasting needs to be improved in order to assist farmers in their activities.

Risk spreading is accomplished through kinship networks, pooled community funds, insurance and disaster relief. In many cases the capacity to adapt is increased through public sector assistance such as extension services, education, community development projects and access to subsidised credit. This further underscores the role of institutions and social networks. Societies have inherent capacities to adapt to climate change, but it is important to note that these inherent capacities may not suffice in the face of not so well understood threats and extreme climatic events, implying the need to complement their capacities with planned adaptive strategies. The adaptive capacity of societies is also considered to depend on the ability to act collectively in the face of the threats posed by climate variability and change (Adger *et al.,* 2003). Moreover, the damage to a system resulting from a discrete hazard event, such as a storm occurring tomorrow, would not be a function of the system's ability to pursue future adaptation strategies – it is existing adaptations resulting from the past realization of adaptive capacity that determine current levels of vulnerability. The likelihood of a system adapting responsively to (as opposed to coping with) a sudden short-lived event such as a hurricane is negligible (Adger *et al.,* 2003).

3.3 HISTORICAL OVERVIEW OF VULNERABILITY AND ADAPTATION TO ENVIRONMENTAL AND CLIMATE CHANGE

Knowledge gaps have been identified between understanding climate variations and human responses particularly in the area of farmer adaptation and future adaptability of agriculture to a variable and changing climate. For this reason, financial and human resources are being allocated to climate change research and there are recommendations for future research to contribute towards an improved understanding of how present agriculture adapts to environmental, climatic and societal factors (Chiotti & Johnson, 1995 and Smit, 1993). Although all in all, historical adaptation to climate change has so far been considered to be remarkably successful, the record of collapsed societies indicates that coping with environmental change in general and climate in particular has not always been easy or successful. Environmental crises are no distinct phenomena of the present. Known environmental crises of the past include the tragedy of the Easter Islands (Diamond, 2005 and Ponting, 1991), the deforestation in ancient Greece (Hughes, 1994), and the overexploitation of biological resources in medieval Europe (Diamond, 2005), among others.

During the course of history many societies that have failed to sustain themselves have vanished. Diamond (2005:34) describes the collapse of a society as the drastic decrease in society's "human population size and/or political, economic and social capacity over a considerable area over an extended time". Reasons that have been cited for the collapse of these and other ancient societies include a runaway growth in human population, consumption and technology that placed an unsustainable burden on all natural systems (Wright, 2004). Four historical civilisations, in particular — those of Easter Island, Sumer, the Maya and Rome — were self-destroyed from a combination of lack of foresight and poor choices that led to overpopulation and irreparable environmental damage. Climatic, geographical and other exogenous factors are considered inappropriate in explaining the different patterns of Easter Island alone, but may have prompted the occurrence of a 'population race' on Easter Island. In analysing these four cases, Wright (2004) notes that Easter Island and Sumer failed largely due to depletion of natural resources, in which case the ecologies were unable to regenerate. Around the year 1400 AD, Henderson Island underwent a severe environmental and cultural collapse similar to the one which destroyed Easter Island society around the same period. This collapse was partially the result of many centuries of supporting the population of nearby islands through trade. A local example in Zimbabwe is the shift from Great Zimbabwe in the fourteenth century, to Dande, by the Munhumutapa who found the population just too big for the available resources.

Though there is no universally accepted theory for the collapse of the Maya, the drought theory is now gaining momentum as the leading explanation. The collapse of trade routes in the Mayan empire would most likely be a temporary phenomenon - or one that resulted from failure of the entire agricultural economy. Furthermore, it is thought that while acute diarrheal illnesses would have been the most devastating affliction on the Maya population, making them more susceptible to other diseases later in life, this is considered to be a minor reason for the Classic Maya Collapse (Gill, 2000). Research on climatic, historical, hydrologic, tree ring, volcanic, geologic, lake bed, and archeological areas demonstrates that a prolonged series of droughts most likely caused the Classic Maya Collapse (Gill, 2000 and Webster, 2002). In addition to these problems that are considered to have caused the collapse of ancient societies, Diamond (2005) identifies four new factors that may contribute to the weakening and collapse of present and future societies. These include human-caused climate change, buildup of toxins in the environment, energy shortages and full human utilization of the Earth's photosynthetic capacity.

Despite the cited failures, the Mayans and Romans left remnant populations that have survived to this day. This fact leads to the suggestion that overall, civilization has done well in their adaptations (Wright, 2004). More importantly, is the fact that communities have managed to survive these climate change challenges in all these periods through trial and error (Burton *et al.*, 2006). Diamond discusses three past success stories of the tiny Pacific island of Tikopia, the agricultural success of central New Guinea and the Tokugawa-era forest management in Japan. While most ancient civilizations depleted their ecologies and failed, there are indications that few thrived. In this respect, Diamond sees "signs of hope" and arrives at a position of "cautious optimism" for the future (Diamond, 2005:25). Societies most able to avoid collapse are the ones that are most agile; they are able to adopt practices favourable to their own survival and avoid unfavourable ones (Diamond, 2005 and Rees, 2005).

Adaptation strategies employed for the survival of the already cited ancient societies include migration. Large expanses of the planet, which is now shrinking, remained unsettled and available for migration (Wright, 2004). In addition, these civilizations experienced greater longevity with use of strategies such as farming methods that worked with, rather than against, natural cycles and settlement patterns that did not exceed, or permanently damage, the carrying capacity of the local environment. More recent investigations have shown a variety of intensive, sophisticated and productive agricultural techniques utilised by the Mayans. These investigations have further revealed that several of Maya agricultural methods gave the Mayan people a competitive advantage over less skillful peoples and have not yet been reproduced (Dunning *et al.*, 2002). Strategies used include canals, terracing, raised and ridged fields and the use of human feaces as fertilizer. Seasonal swamps or *bajos* and using muck from these *bajos* to create fertile fields, dikes, dams, and irrigation and water reservoirs also formed part of the intricate strategies used by these ancient people. In addition, they employed several types of water storage systems, hydraulic systems, swamp reclamation, swidden systems and other agricultural techniques which are yet to be fully comprehended (Dunning *et al.,* 2002). 'The Mayan people thrived in what to most peoples would be uninhabitable territory. Their success over two millennia in this environment was "amazing" (Demarest, 2004:129)

3.4 ENVIRONMENTAL CHANGE, VULNERABILITY AND ADAPTATION

3.4.1 ENVIRONMENTAL CHANGE: NATURAL OR HUMAN INDUCED?

Global Environmental Change (GEC) is as old as the planet Earth. The concept refers to "those changes that modify substantially, sometimes irreversibly, the character of the Earth System and, therefore, influence, be it directly or indirectly, natural life support systems for a large part of humanity" (WBGU, 2005; 59). While physical, chemical and biological processes have been shaping and reshaping the earth's environment since its infancy 4.5 billion years ago, in recent times; humankind has been one of the major driving forces of global environmental change, including climate change, deforestation and loss of biodiversity, pollution and desertification, among other changes. In extreme cases, such changes often trigger environmentally-induced population displacement (WBGU, 1993 & 2005). Although most environments are in a constant state of flux, human modifications for food production, settlements, infrastructure, or to produce and store goods, accelerate the rates of change in many cases outside the range of natural disturbances and fluctuations (Drimie & Van Zyl, 2005). Global environmental changes can, therefore, have both natural and anthropogenic causes and the latter are characterised by their high speed in contrast to the former (Jagger, 2000 and WBGU, 1993 & 2005).

Literature traces the trajectories of the exploitation of the environment by hunter gatherer societies (Fischer-Kowalski & Haberl, 1997) to colonisation in agrarian societies (Grigg, 1980) - a period in which societies started to deplete their resources - and then to industrial societies. These processes are considered to have gradually led to the environmental change that characterises societies today (Fischer-Kowalski & Haberl, 1997 and Weisz *et al.,* 2001). Most scientists concerned with environmental damage concur that the current processes of global environmental change are best described as unsustainable. A commonly accepted formulation of global environmental change as a scientific issue says that the 21st century faces a unique problem, namely, an anthropogenic environmental crisis of global dimensions, which can be traced back to the beginning of industrialization (Stern *et al.*, 1992 and Weisz *et al.,* 2001). Changes brought on by the exponential growth of human population and the worldwide scales of resource consumption are considered to have contributed to global environmental change. For instance, the world's population was estimated to be approaching seven billion in 2009, adding over 70 million people every year. In terms of resource consumption, an area of farmland the size of Scotland has lost to erosion every year. Ecological markers now indicate that since the 1980s, human civilization has surpassed nature's capacity for regeneration. Humans in 2006 used more than nature's yearly output annually: "If civilization is to survive, it must live on the interest, not the capital of nature" (Wright 2004; 129).

Environmental Hazards

For over two decades now, a new perspective has emerged that views hazards as basic elements of environments and as constructed features of human systems rather than as extreme and unpredictable natural events, as they were traditionally perceived. Natural hazards, traditionally studied as earthquakes, droughts, floods or intense rains (White, 1974), took on a new dimension to the extent that they came to be considered as inserted in societal dynamics and in the more encompassing perspective of environment. Natural hazards, therefore, became environmental hazards (Oliver-Smith, 1996 and Smith, 2004). Natural disasters are primarily caused by natural factors or induced by human activities and have strong impacts on societies. While economic losses reported by insurance companies are mainly located in developed countries, other impacts on lives and livelihoods are a major concern for developing countries which account for 85% of the people affected by environmental hazards. In the same respect, climate-related hazards and climate change affect a wide range of ecological systems which include forests, grasslands, wetlands, rivers, lakes and marine environments. In addition, human systems such as agriculture, water resources, coastal resources, health, financial institutions and settlements are also affected (IPCC, 2001).

While droughts, earthquakes, cyclones and floods were responsible for about 94% of the total casualties globally, volcanoes, extreme temperatures, landslides, tidal waves and wildfires accounted for the remaining part (Dao & Peduzzi, 2004). More disturbing is the fact that for the period 1980-2000, up to 119 million people in 84 countries were exposed each year to cyclone hazards, with a total death toll of 251 000 world-wide. Moreover, it was revealed through geo-spatial modelling that during the same period between 1980 and 2000, millions of people were exposed to drought hazards every year, causing a total of 832 000 deaths. In the same period, a further 130 million people per year were exposed to earthquakes, with a total of 159 000 killed. However, the case of drought is considered to be still fuzzy due to the difficulty of defining and mapping drought hazards, as well as to the high sensitivity of the model (Dao & Peduzzi, 2004). According to figures by the Belgian WHO collaborating Centre for Research on Epidemiology of Disasters (CRED), the year 2007 saw a considerable increase in the number of flooding disasters. Asia was hit hardest by these disasters compared to the average flooding data of the period beginning 2000. In the same respect, eight out of the 10 countries with the highest disaster deaths of 2007 were in Asia, with 4 234 killed in Bangladesh by cyclone Sidr. The World Bank's Global Hotspots Study found that 25 million km^2 and 3.4 billion people are highly exposed to at least one natural hazard with 105 million people highly exposed to three or more hazards (Velasquiez, 2007).

The background cited above is considered to be changing the face of disaster risks, with vulnerability to hazards increasing rapidly. Climate-change-specific impacts such as sea-level and temperature rise and glacier melting, among others, are expected to aggravate existing vulnerabilities to disasters. In addition to the changing vulnerabilities, there have been observed changes in hazards- increased intensity and/or frequency of known hazards, and a shift in the distribution of existing hazards, with some regions expected to face hazards that they have not experienced in the past (Velasquiez, 2007).

Vulnerability to environmental hazards

Disaster statistics reveal that natural hazard impacts are unevenly distributed around the world. Certain countries, regions and areas are more vulnerable than others because of various factors such as geographic location, climate, geology and capacity to cope with extreme conditions. Developing countries are particularly affected by climate change, because climate-sensitive sectors, such as agriculture and fisheries, tend to be very important from an economic standpoint. Moreover, developing countries have limited human, institutional and financial capacity to anticipate and respond to the effects of climate change (IPCC, 2001 and Thomalla *et al.,* 2006). In terms of their spatial distribution, environmental hazards affect socio-economic groups differentially. While some hazards are widespread and affect all groups (snowstorms, earthquakes and drought), others occur in areas in which the primary population group exposed tends to be poorer as residence in these hazard-prone areas is generally tied to privation and poverty (floods and landslides) (Marandola & Hogan, 2006). A greater proportion of the poor and marginalised people are directly dependent on ecosystem services for their livelihood activities and may, therefore, be vulnerable to changes in environmental conditions and factors that may limit their access to such resources (Task Force on Climate Change, Vulnerable Communities and Adaptation, 2003). Institutional, political, economic, cultural and geographical factors all contribute to vulnerability, with distinct differences among persons and places (Marandola & Hogan, 2006).

Factors that heighten vulnerability to environmental disasters include complex interactions of social, economic and environmental factors operating on different spatial and temporal scales, which affect the ability of individuals and communities to prepare for, cope with, and recover from disasters. Environmental hazards may be provoked by population density or patterns of population mobility and distribution. In this regard, factors such as soil degradation and deforestation, which are implicated in causing floods, have been associated with population increase. The construction of large reservoirs or pumping waste into the ground and oil and water out of it, both associated with population density, have also been implicated in earthquake incidence (Bohle *et al.,* 1994; ISDR, 2002; McPhee, 1989).

Access to social and financial resources, information and technology, as well as the effectiveness of institutions also determine people's vulnerability to environmental hazards (Thomalla *et al.*, 2006). Particular social groups tend to be the most vulnerable to environmental hazards. These include women, the elderly, children, ethnic and religious minorities and single-headed households. In addition, socially excluded groups such as "illegal" settlers and others whose rights and claims to resources are not officially recognised, are considered to be more vulnerable to environmental hazards. In other cases, people engaged in marginal livelihoods and those with inadequate access to economic (credit, welfare) and social (networks, information, relationships) capital is also considered to be vulnerable to hazards (Thomalla *et al.,* 2006).

A stronger dependence on agriculture has been shown to induce higher vulnerability. For instance, after a cyclone, an economy relying on a tertiary sector is less affected than one relying on agriculture. The same results depict that less developed countries are more vulnerable to cyclones than developed countries (Dao & Peduzzi, 2004). Moreover, regression analysis shows that urban growth, together with physical exposure, is statistically associated with the risk of death to earthquake. Levels of risk are influenced by the factors linked with rapid urban changes, like poor building quality (Dao & Peduzzi, 2004). About 196 million people in 90 developing countries were annually exposed to floods between 1980 and 2000, with a total of 170 000 deaths during the same period. The variables selected by the statistical analysis are physical exposure, gross domestic product per capita and local density of a population. It is not surprising that the regression shows that highly exposed and poorer populations are more subject to suffer casualties from floods. However, it is surprising that countries with low population densities in exposed areas are more vulnerable than countries with high population densities. Although this has been attributed to a higher level of organisation in denser areas, it still has to be confirmed in future research (Dao & Peduzzi, 2004).

Age structure is another factor that has been linked to vulnerability to environmental hazards. Infants, children and the elderly have been shown often to be at greater risk, and nearly always have fewer resources to support coping with disaster. It, therefore, becomes important to plan for the numbers of elderly requiring assistance in fleeing storms, in seeking relief from heat waves; and in coping with sudden events like earthquakes or tsunamis. Moreover, urbanization is an important phenomenon in the context of human vulnerability to environmental hazards. This is another of the demographic processes which is considered to create and magnify natural hazards (UNFPA, 2007).

Disaster reduction and adaptation

Disasters are considered to signal the failure of a society to adapt successfully to certain features of its natural and socially constructed environment in a sustainable fashion (Dao & Peduzzi, 2004). With increasing frequency and intensity, environmental hazards are likely to affect growing numbers of persons, requiring societal – and no longer merely sectoral – interventions (Marandola & Hogan, 2006). In addition, disasters are fundamentally the outcomes of interactions that occur at the interface of society, technology, and the environment. In this regard, they become a formidable test of societal adaptation and sustainability. For a society to be considered to have developed in a sustainable way, it must be able to withstand without major damage and disruption a predictable feature of its environment (Oliver-Smith, 1996). While non-anthropological disaster research has generally portrayed traditional societies as vulnerable and unable to cope with a continual reign of terror from the environment, anthropology has demonstrated the resilient and adaptive capacities with which traditional peoples respond. Moreover, indigenous adaptations in traditional contexts may have allowed for reasonably effective responses to hazards (Oliver-Smith, 1996). It would, therefore, be a mistake to underestimate the importance of local strategies and community-based experiences in vulnerability reduction. Local level strategies and self reliance are viewed as meaningful cultural responses which produce lasting and important effects on the capacity of people and places to adapt and respond to risk especially in less favourable economic settings. At the centre of this successful adaptation is the territorial and cultural link that enhances social strategies which permit significant advances in protection and increased security, even in the absence of significant economic investments or direct state interventions (Delica-Willison & Willison 2004; Heijmans 2004).

At a broader level, a number of actions that can be taken to reduce vulnerability to natural hazards and adapt to climate change include the promotion of a culture of prevention and resilience, the development of institutions- policies, planning, legislative and multi-stakeholder mechanisms- to actively contribute to these goals. In the same respect, identification of risks through risk mapping and hazard and vulnerability assessments is important. The promotion of early warning systems, building of hazard resistant structures such as schools and hospitals and protection and development of hazard buffers (natural ecosystems such as forests, reefs, and mangroves) are important in dealing with environmental hazards. Furthermore, disaster preparedness, response, and the development of pre-disaster recovery plans need to be enhanced. For instance, housing safety education in Jamaica after Hurricane Gilbert has been explored as a mitigation strategy, as much as government food distribution programmes in drought caused emergencies in India (Oliver-Smith, 1996 and

Velasquiez, 2007). However, these actions at a broader level can be linked to local actions; for instance, local people are usually the first respondents and can therefore be effective in limiting short- and long-term losses.

The disaster risk management community focuses on a vast assortment of natural and man-made hazards, of which climate-related hazards only represent one particular area. Disaster risk management has traditionally involved natural scientists and civil engineers and concentrated on short-term single stressor responses through structural measures such as flood embankments, community shelters and more resistant buildings. The latter were intended to control natural processes in a way that would either modify the threat or provide physical protection with regard to lives, property and critical infrastructure. There has been a strong emphasis on developing capabilities for hazard forecasting and providing immediate humanitarian relief once a disaster struck (Thomalla *et al.,* 2006).

3.4.2 CASE STUDIES OF VULNERABILITY AND ADAPTATION TO ENVIRONMENTAL CHANGE IN AFRICA

Introduction

Three environmental transformation processes are regarded as the core of global environmental change: climate change, loss of biodiversity and the depletion of stratospheric ozone (Stern *et al.*, 1992). In the same respect, WBGU considers the following environmental change issues to be particularly relevant to the poverty-environment nexus: climate change, water scarcity, pollution, soil degradation, loss of biological diversity and resources, air pollution and toxic substances. Similarly, Drimie & van Zyl (2005) assert that environmental changes brought about by human activities set in motion a chain of changes which make us more vulnerable to disasters such as desertification (loss of vegetation cover), which leads to reduced soil moisture and affects agricultural productivity. Increased soil erosion and runoff lead to increased flood volumes and poor water quality due to elevated suspended solid levels.

With the increasing recognition that future climate and other environmental changes may pose a serious threat to society, or some groups within society, the question of how to adapt to these changes is now receiving attention from researchers, governments and organisations (Boko *et al.*, 2007; Burton *et al.,* 2002; Cooper *et al.,* 2007; Deressa *et al,.* 2008; Smit *et al.,* 1999; Smit & Pilifosova, 2001 and Subak, 2000). For instance, several stakeholders are now looking at how smallholder farmers are changing methods in order to continue producing under conditions created by climate change. Literature shows that some of the adaptation measures that have been used by farmers are individual measures while others are collective group actions. It provides for the fact that farm-level decisions, including adaptive responses, are shaped by two general sets of variables: those that operate at the individual farm level, and those that operate at scales beyond. This approach thus provides a broader appreciation of the non-climatic and societal forces which influence farm-level decision making, and a larger set of adaptive responses that could be employed by farmers (Adger, 2003; Chiotti & Johnson, 1995; Downing *et al.*, 1997 and; Tol *et al.*, 199 & 2004).

The following section focuses on case studies of vulnerability and adaptation to land degradation, climate change and cyclones. These environmental changes have been selected as they cut across the environmental changes that have been cited in this chapter.

Case study one: Land degradation in Karamoja, Uganda

Introduction

This study was done by Moyini in 2004 in the Karamoja region within Uganda (UNEP, 2004). This region is considered to be unique in that it is becoming increasingly semi-arid to arid due to land degradation and is progressing towards desertification (Gissat, 1997 and NEMA, 1998; UNSO/GoU, 1991). Karamoja occupies an area of 24 000 km^2, which is approximately 10% of the size of Uganda. The region consists of the districts of Kotido, Nakapiripirit and Moroto. Karamoja experiences extreme levels of climate variability and rainfall varies from 300 mm in the dry steppes on the lower levels to about 900 mm in the montane climates of Moroto and Zulia (Kajura, 2000). In this case study, environmental change is understood to embrace stresses and shocks - the cumulative effect of land degradation and periodic droughts. Human vulnerability in this case is expressed in terms of poverty, food insecurity and conflicts over natural resources resulting in loss of property and lives, and epidemics at both individual and household levels (Moyini, 2004). In short, this study deals with the impact of environmental change, in this case land degradation, on the vulnerability of the people of the Karamoja region and the neighbouring communities.

Pressures on the environment in Uganda

In Karamoja, the main causes of land degradation include a high population growth rate, excessive clearing of forests and woodlands and overgrazing. Poor crop cultivation and poor bush fire management have also been implicated in causing land degradation in this region. A dramatic increase in the population of Karamoja is shown in the latest census results. Aggregate land area per person declined from 10.1 ha in 1969 to 2.9 ha in 2002. Protected areas in this region, which constitute about 48% of the land area, indicate a decline from 5.3 ha in 1969 to 1.5 ha per person in 2002 (Moyini, 2004). In the same respect, all forested areas in the region, including those that have been gazetted reserves, have been encroached upon over the years. The main reasons for this encroachment include over cutting of trees for fencing of cattle pens, fuel wood and building poles, uncontrolled bushfires during the clearance of land for cultivation and clearance of bush land for cultivation (Forest Department, 2002a & 2002b and NEMA, 1998).

The traditional occupation of men in Karamoja is livestock rearing on the nomadic system and cattle occupy a very important place in the culture and social life of the Karimojong. For this reason, excessive grazing of vegetation has led to the wholesale destruction of grass and shrubs. There has been a discernible decline in the area available for cattle grazing in Karamoja between 1930 and 1998. Moreover, the concentration of livestock within relatively smaller areas has meant that diseases can spread quickly (UNSO/GoU, 1991). Water for livestock constitutes a significant source of demand, especially in the semi-arid and arid areas of Karamoja where surface water sources are scarce and long dry periods are common. The annual demand for water by livestock in Karamoja is expected to increase from 1.2 million m^3 in 1989 to 2.1 million m^3 by 2010 (DWD, 2005).

Land degradation through poor crop cultivation practices has links with soil degradation, which occurs in two major ways: the practice of monoculture and shifting cultivation. In monoculture, sorghum is planted in the same field year after year, leading to depletion of soil fertility. In shifting cultivation, a piece of land is cultivated for a number of years until it is incapable of producing any crop due to top soil exhaustion. This process is repeated on fresh land as the homestead is shifted to a new location. The soil no longer has time to recover with the increase in population (Gissat, 1997). Similarly, Ugandans living in predominantly rangeland areas engage in setting annual bushfires. In Karamoja, these bush fires are started by pastoralists to replace forest vegetation with grassland and by honey gatherers in the dryland forests. These fires are known to cause land degradation (NEMA, 2001).

Impacts of land degradation in Uganda

The key impacts of land degradation in Karamoja are increasing soil erosion, greater dependence on biodiversity resources and escalation of conflicts, poverty and food insecurity (Moyini, 2004). The extent of soil erosion in Karamoja is medium to high. High rates of surface run-off and erosion have been reported from heavily grazed and/or annually burnt grasslands in a number of studies. In addition, the short-lived rains are torrential and produce a great deal of run-off on the bare ground with poor infiltration capacity. As a result, gullies sometimes as deep as 2-5 metres have been created on the steep slopes. In the relatively flat areas, sheet erosion is rampant and erosion in turn results in reduced agricultural productivity of the soils and scarcity of water and pasture for livestock (Gissat, 1997).

With increasing population in Karamoja, the rate of extraction of forest products is increasing and fast approaching unsustainable levels. To the different Karimojong groups, the forest reserves offer refuge during cattle raids and a source of water and pasture during the dry periods. Other resources such as charcoal as a source of income, which when combined with uncontrolled grazing in the forests, contribute to the loss of biodiversity and forest cover (Moyini, 2002).

Escalation of conflicts is one of the manifestations of environmental change in Karamoja. Before colonial administration, there were conflicts between pastoralists and agriculturalists over land. Moreover, among pastoralists themselves, there existed conflicts over livestock grazing areas and water points. There is also clear-cut conflict between pastoralists and the (post-independence) government centering on different conceptualisations of patterns of production. While pastoralists insist on a nomadic way of life, government and NGOs advocate for permanent settlement as the solution to the Karamoja crisis (Emunyu, 1992). With increasing impacts in Karamoja, these conflicts are reported to have also increased. For instance, the Karimojong have generated conflicts with neighbouring districts in an attempt to move westwards in search of water and pasture especially during the dry season (Emunyu, 1992).

Unlike other parts of Uganda where poverty has been on the decrease since 1992, the situation in Northern Uganda, including Karamoja is different as the level of poverty is on the rise. Because of the long dry seasons, those who are cultivating crops in Karamoja can only have one harvest a year, which is further made uncertain by the erratic rains and soil degradation. For instance, in Kotido district, production of cereal was 33 134 metric tons, which represented only 22% of the 148 200 metric tons required for self sufficiency. Moreover, malnutrition is one of the major problems especially among the pastoralists groups and is a major cause of infant mortality (KDC, 1995). Subsequently, relief food supplies in this region have led to a dependency syndrome, which has practically replaced agricultural production (Moyini, 2004 and NEAP Secretariat, 1993).

Responses to impacts of land degradation in Uganda

Responses to deal with land degradation include raiding cattle to restock, external mobility (moving outside Karamoja to source pastures) by the Karimojong and disarmament, provision of water sources, greater efforts aimed at the conservation of biological resources and modernisation of agriculture by the government and its development partners (Moyini, 2004). Responses by the Karimojong have led to higher levels of vulnerability for them and their neighbours. The key response by pastoralists is mobility in a bid to enhance the carrying capacity, which has, however, led to further environmental degradation. Raiding cattle is also a survival response which has been known to occur when livestock have been lost to raids or when they have been confiscated by the administration. This has, however, led to conflicts and has been linked to the spread of diseases such as rinderpest and trypanosomiasis as communities that are raided are forced to restock from other areas (NEAP Secretariat, 1993; Otim *et al,*. 2001 and Fevre, 2002).

There have been efforts by various Ugandan governments to disarm the Karimojong, who have had firearms since the 1800s, with limited success. They have now acquired sophisticated AK 47s that facilitate cattle raids for restocking, personal wealth accumulation and provision of dowry. It is estimated that while the Karimojong have 40 000 weapons, by 2002 only 7 065 had been collected and it was feared continued efforts of disarmament could lead to further instability (USAID, 2002). By June 2002, a total of 802 boreholes had been drilled and valley dams and tanks developed in Karamoja by government and NGOs. Of these 300 were functioning with some not functioning due to lack of maintenance. Other boreholes failed to produce water due to the difficult geology of the area (Tushabe, 1994). However, the use of valley dams and tanks has had significant adverse environmental effects in Karamoja as vegetation within a distance of 0.65 km around valley dams was destroyed due to over concentration of livestock and the problem of siltation arose, coupled with the high cost of maintenance of these valleys and dams (Kajura, 2000 and Nimpamya, 1998)

Case study two: Climate change in Burkina Faso

Introduction

Burkina Faso's economy is based mainly on agriculture, which provides livelihoods for 80% of the population. Agriculture has, however, been threatened by the fact that the country has been receiving less and less rains. In the particular season that this study was done by Sawadogo (2007), the heat wave that started in March had not yet, two months later, given way to the first rainfall of the new farming season, except in a few isolated parts of Burkina Faso. National experts in this country expect this climatic scenario to persist and even get worse with average temperatures increasing by 0.8% by 2025 and by 1.7% by 2050. Moreover, the average annual rainfall could decline by 3.4% by 2025 and by 7.3% by 2050 (Sawadogo, 2007). In this case study, Abel Raogo, a 60 year-old farmer in the village of Ipelcé, some 50 km from the capital, has already finished sowing his fields and awaits the rains. In the same respect, Hamadou Tamboura farms and raises livestock near Sapouy, in a neighbouring province. He moved there five years ago from the arid Sahel region in Burkina's north. Both farmers live in different provinces, but are faced with similar challenges. They are both aware that the conditions they confront are no longer what they once were. There were times when farming could begin in April with plentiful and lasting rains, but those years are long gone. The farmers give a time frame of approximately forty years when they were not as concerned about poor harvests as they are presently. The two farmers have seen the reality of the changing weather, although they are not sure of the reasons.

Pressures on the environment in Burkina Faso

Sawadogo (2007) cites natural constraints such as degraded soils, recurrent droughts, deforestation and spreading deserts as having a major impact on farmers in the study areas. These constraints combine to make people's lives more vulnerable. Human activities, including excessive cutting of trees, overgrazing by livestock and more intensive farming, have also been implicated in environmental deterioration. Other human activities putting pressure on the environment include the uncontrolled clearing of land, poaching of wildlife and migration of livestock, as herders from the north search for new pastures, all of which are considered to worsen the impact of climate change. Moreover, parts of the country which are rich in natural resources and generally have more favourable weather are increasingly hit by high temperatures and pockets of drought. These include the eastern and western parts of the country. It is, therefore, ironic that the north, which usually has Burkina Faso's lowest average rainfall levels, has in recent years sometimes experienced unexpectedly heavy rains. An example of this is a downpour in Oudalan province, which caused serious flooding with widespread property damage in August 2006. Similarly, sandstorms, which normally hit only the northern parts of the country, now affect other regions as well.

Impacts of climate change in Burkina Faso

Sawadogo (2007) cites a number of impacts of the frequent extremes of climate experienced in Burkina over the past four decades. Drought in the 1970s caused a serious famine and cost numerous lives and major livestock losses. Since then, famine has been less severe, but remains a frequent phenomenon in parts of the country. Also disturbing is the fact that desertification has become rampant in Burkina Faso. Desertification has been linked to climate change and there is evidence that desertification influences local climate patterns, while climate variations in turn affect the process of desertification. In a 2006 study done by an inter-ministerial coordinating body that also included independent experts and civil society representatives, it was found that there were four sectors that were most vulnerable to climate change: water, agriculture, stock raising and forestry. The silting and evaporation of lakes and rivers and a long-term decline in the capacity of water reservoirs was found to have resulted from lower rainfall and higher temperatures. For instance, three-quarters of the 84 dams and reservoirs in the Central Plateau region are silted and require rehabilitation. Equally disturbing, some dams and reservoirs no longer enable farmers to produce crops as these dams no longer hold enough water during the dry season. Soil degradation and high levels of water evaporation from dams contribute to the spread from the north of agricultural pests such as locusts and results in lower crop yields and reduce biodiversity. Soil degradation in Burkina Faso is estimated to be affecting 30% of the total land.

Responses to climate change in Burkina Faso

Responses to climate change are at two levels, i.e. responses at the local level and at national level. Local responses to climate change by farmers are limited and this poses a major concern of how farmers can be able to escape poverty if they lack a diversified package of adaptation strategies to climate change. To address the challenge of water scarcity, farmers in Burkina Faso, as an alternative to rain-fed farming, grow vegetables irrigated by dam water. In addition to this, they dig wells and small water reservoirs to supplement water for their crops. For instance, a farmer, Albert Bouda, grows vegetables in fields irrigated by the Goué dam, near Ouagadougou. Migration of farmers and herders and their livestock is another way in which farmers have sought to offset the challenges brought about by changes in climate. For instance, Tamboura decided to move to Sapouy to escape the hard conditions of the Sahel's hostile environment and seriously degraded land (Sawadogo, 2007).

At national level, Burkina Faso was one of the early signatories of the United Nations Framework in 1992. In addition, the government drafted in consultation with civil society organizations and community representatives, the National Adaptation Plan of Action (NAPA), which is intended to identify immediate needs and projects to help local communities deal with the adverse effects of climate change. The idea behind drafting the NAPA was not only to counter the current negative impacts of climate change, but also to anticipate their consequences and the rise of new threats. In addition to government efforts, many civil society groups and non-governmental organizations (NGOs) are active around environmental issues in Burkina Faso. They assist farmers in conserving water, topsoil and vegetation. Introduction of practices that preserve the environment and increase yields has also been done. A case in point is a project for women who conserve shea trees and other plants that can provide farmers with additional sources of income that has been introduced by an organization called the Ragussi Association. However, the major challenges that lie in the implementation of these plans are twofold: the available resources are limited in successfully countering the adverse impacts of climate change, which will require the involvement of all national actors from the government down to local communities; and over reliance on international intervention becomes problematic when these donors leave and farmers run the risk of developing a dependency syndrome.

Case study three: Cyclones in the Indian Ocean Commission countries

Introduction

This case study was conducted by Roberts (2004) and the location of the study area is on the western Indian Ocean Commission (IOC) countries, which encompass Comoros, Madagascar, Mauritius, Reunion and Seychelles. The total population of these islands is 17.5 million and they are subject to seasonal tropical storms (cyclones). A cyclone is defined as an intense tropical storm with wind speeds of greater than 117 km/h. The cyclonic season starts in November and ends in mid-May (DMSP, 2002). The Seychelles group of islands is less affected by cyclones as they are located closer to the equator, but rain generally affects social and economic activity there. Madagascar suffers from cyclones on average four times a year, causing significant damage (UNEP, 1999). The Mascarene Islands (Reunion, Mauritius and Rodrigues) are hit on average once every four years by a severe tropical cyclone, normally causing severe damage.

Pressures on the environment in the Indian Ocean Commission countries

Flooding, soil erosion and contamination of freshwater are some of the pressures on the environment emanating from the high incidence of cyclones in Madagascar and other IOC countries. The destructive power of heavy winds, rains and projectiles caught in the storms inflict severe damage on agriculture and the environment in general.

Impacts of cyclones in the Indian Ocean Commission countries

Some of the impacts of cyclones on the IOC countries are crop and livestock losses, loss of life and damage to physical and human environments as well as consequent socio-economic problems such as famine, increases in the cost of living and theft. The people in these islands are vulnerable as they have crops and livestock, live near the coast in insecure dwellings and are dependant on subsistence agriculture, which is subject to the destructive power of the cyclones. Deaths, property and infrastructure damage and social losses from cyclones have been recorded. In Seychelles in 1997, torrential rain and flooding set a government housing programme back by two to three years. What is more disturbing is that cyclones occur without warning, meaning that the local populations are rarely prepared for a response to warnings (Roberts, 2004). Deaths due to cyclones between 1980 and 1999 in the countries under discussion are presented in Table 2.

Table 2: Human impacts of cyclones in the Western Indian Oceans (1980-1999)

Country	Total population (mil)	Deaths/million 1980-1999	Rank by deaths/million
Madagascar	15.1	113	3
Comoros	0.7	1312	1
Mauritius	1.1	151	2
Seychelles*	0.1	50	4

Source: UNDP (2000)

*Figures for Seychelles are for 1996-98

Responses to cyclones in the Indian Ocean Commission countries

In this case study, Roberts (2004) analyses response to cyclones at national level and overlooks the importance of documenting and analyzing local responses, which may be used as a springboard to understand adaptation to environmental hazards and make recommendations for future policy making. Precautionary measures in parts of the IOC have been provided with support from the EU. The development of early warning measures and general extension of systems with satellite monitoring are some of these measures.

These early warning systems have given rise to the prospect of further substantial reductions in impacts of cyclones and have provided clear advantages for the health and welfare of the people of Mauritius and Reunion. These measures were expected to provide security to the IOC countries for five to ten years. Countries such as Comoros and Madagascar would benefit more if other aspects such as more robust construction of dwellings and public infrastructure were considered. Madagascar seeks regular international aid to help in rehabilitation works, reconstruction and security (UNEP, 1999). However, it was acknowledged that further measures were needed in the countries worst hit by the impacts of cyclones.

3.5 LESSONS LEARNT FROM CASE STUDIES

It is important to take note of lessons that can be drawn across the case studies outlined in Section 3.4.2. There is an indication that farmers are aware of climate change and are able to suggest a time frame of the onset of these changes in climate, for instance, farmers in Burkina Faso indicated that the changes had started about 40 years ago. However, the fact that the same farmers have no idea about the causes of climate change is of immediate concern. Also of importance is the fact that it is fundamental for this study to understand how climate change may be compounded by multiple stressors. Across the cited case studies, challenges include deforestation, uncontrolled fires, crop and livestock pests and diseases, among others. These challenges may be either climate or non-climate related. Essentially, while climate extremes such as droughts and floods may be the most critical challenge, farmers have a host of other factors to contend with. Equally important is the idea that there may be both positive and negative impacts emanating from climate change and other pressures. For instance, while a great deal of environmental degradation may arise from the commercialisation of forests, factors such as job creation and an increase in income may be registered.

There is an indication that farmers and rural communities do respond to climate change and other related pressures through measures such as vegetable irrigation, digging wells and creating small reservoirs, migration and establishing local social networks that they draw from in times of crises. At national level, governments have started drafting policies and legislative frameworks that are intended to mitigate and adapt to climate change. However, it is important to note that while response measures may go a long way in cushioning communities and governments against crises, the same measures may fall short of achieving the intended goals. For instance, social networks in different groups were highlighted as having created heterogeneity, which in turn compromises effectiveness. In this respect, these social networks were subject to manipulation by elites, heightening vulnerability levels for weaker groups such as women groups. Similarly, creation of a regulatory framework may not be effective especially where there are inadequate skilled personnel to administer and police the framework.

3.6 CONCLUSIONS

This chapter has shown that adaptation to environmental and climate change is not a new phenomenon, but has been traced back to ancient societies. It may, therefore, be important to understand how these societies succeeded or failed so as to either build on the strengths or improve on the weaknesses of these predecessors for the benefit of modern societies. In addition, it is important to understand that climate change is just one of a plethora of environmental changes that bedevil the livelihoods of both urban and rural populations. Case studies also presented in this chapter suggest that while adaptation must take place at all levels at the same time for it to be most effective, it is most important to acknowledge that adaptation is inherently and fundamentally local. It is, therefore, important to understand adaptation processes at local level and make recommendations for policy makers. Moreover, although the direct impacts are felt locally, adaptation efforts must be backed by national policies and strategies for them to be robust. It is also important to note that while the cited survival strategies adopted by farmers and communities may assist them to cope with a changing environment and climate, these strategies may push these farmers and communities into a cycle of poverty either by creating a dependency syndrome, triggering conflicts and a spread of disease or weakening traditional social networks. At national and international levels, there is need to strengthen policy and legislative frameworks that govern environmental management and ensure that the relevant departments and ministries are well manned. Chapter Four presents the methodology and analytical framework for this study.

CHAPTER 4: METHODOLOGY AND ANALYTICAL FRAMEWORK

4.1 INTRODUCTION

This chapter presents a general background to the study sites and the methodological and analytical frameworks adopted for the study. It is divided into three parts. Part one gives a description of the study sites. This description focuses on the location of the districts, the physical environment and the socioeconomic context of these sites. Part two highlights the distinction between the methodological approaches which formed the basis of this study, that is, the qualitative and quantitative approaches. The research strategy, data requirements and sampling procedures are highlighted next. The section that follows centres on the specific data collection methods that were used under the qualitative and quantitative approaches. Part three presents the analytical framework that was used to explore relevant issues investigated in the study. This part is divided into two sections. The first section highlights the Sustainable Livelihoods Approach and its relevance to this study. The second section outlines the researcher's own construction of a framework for understanding linkages in farmer perceptions of climate change and climate change impacts and adaptation by farmers.

4.2 DESCRIPTION OF THE STUDY AREA

The study was conducted in semi-arid Monze and Sinazongwe districts in Southern Zambia as well as Lupane and Lower Gweru districts in South-Western Zimbabwe (Figure 1). The idea was to come up with districts located in contrasting agro-ecological zones within each country for comparative purposes, that is, areas that receive below normal rainfall and those that receive normal to above normal rainfall (see detailed contexts in the following sections). It was important to investigate the differences in farmer perceptions, climate change and variability impacts and subsequent adaptation strategies by location.

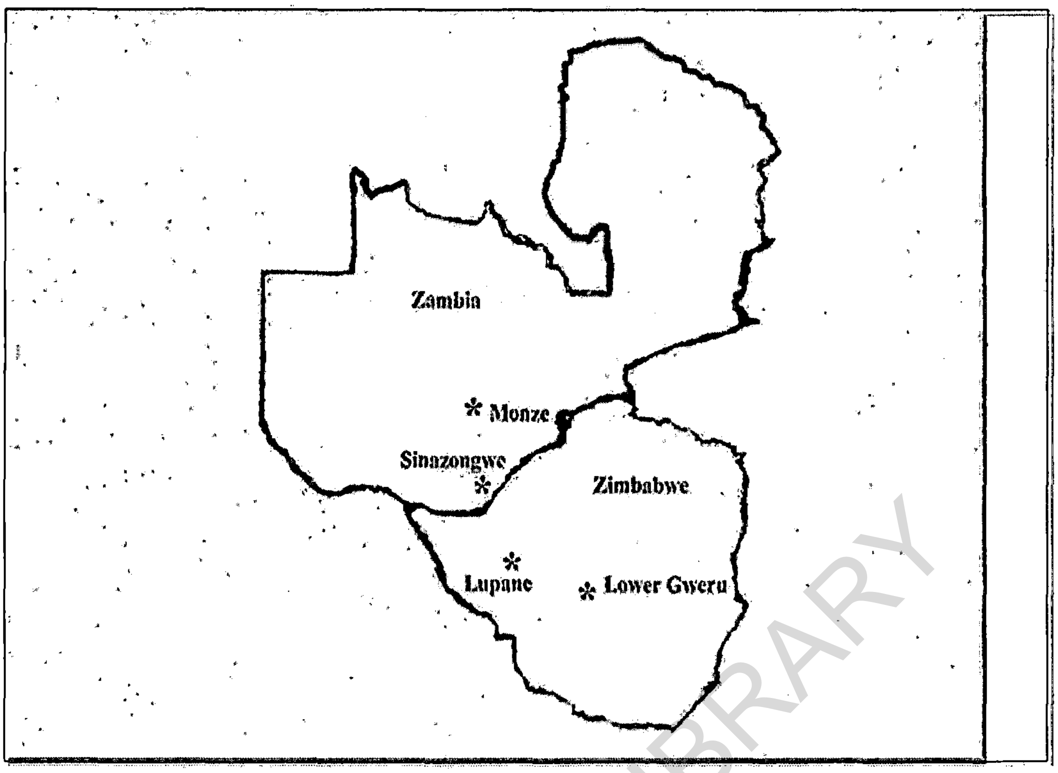


Figure 1: Location of study districts in Zimbabwe and Zambia

4.2.1 BACKGROUND INFORMATION ON LUPANE AND LOWER GWERU DISTRICTS IN ZIMBABWE

Zimbabwe is a landlocked country in the Southern African region, with an area of 390 760 km^2. It lies within the tropics between 15° 30' S and 22° 30' S and 25° E and 33°E. Moreover, running from north to south along the eastern border with Mozambique, there is a narrow belt of mountains (2000–2400 m), the Eastern Highlands. The deep cleft of the Zambezi River Valley forms the boundary with Zambia in the northwest (Mano & Nhemachena, 2006).

The mean annual rainfall in Zimbabwe varies from below 400 mm in the extreme south of the Lowveld to above 2 000 mm on isolated mountain peaks in the Eastern Districts. Middleveld rainfall ranges from 500 mm to 700 mm and that of the Highveld from 800 mm to 1 000 mm. The rainfall pattern in Zimbabwe is distinctly seasonal, with approximately 90% falling in the six months from 1 October to 31 March. There are three distinguishable seasons; a hot and dry spring from mid-September to the onset of the rains, a hot, but moist summer covering the rainy season and a dry winter period consisting of cool nights and warm cloudless days lasting from April to September. In the communal areas of Zimbabwe, while relatively infertile soils cover some two-thirds of the country and the main soil type is sandy in nature, there are isolated areas of heavier, more fertile soils throughout the country, the largest pockets being on the Highveld. Fertile irrigable basaltic vertisols occur extensively in the southern Lowveld (Mano & Nhemachena, 2006).

Zimbabwe is also made up of ten provinces which include two cities with provincial status, Harare and Bulawayo. The country is also characterised into agro-ecological regions I to V based on rainfall, vegetation and other agro-ecological factors (Vincent & Thomas, 1960) (see Table 3). The different percentages of the type of farming by agro-ecological regions and the changes that these types of farming have undergone in the period 1980 to 2006 due to the land reform[10] are presented in Tables 3 and 4 respectively. The illustration in Table 4 indicates that farming systems may as a result have been altered significantly. Areas that fell under commercial farming have been transformed and become communal, which has had implications for the livelihoods and economy of the nation as a whole, considering that the Zimbabwean economy is agriculture based. The agro-ecological zones and the research sites are presented in Figure 2.

Table 3: Zimbabwe Agro-ecological Regions

Natural Region	Area (km²)	% total land used for agric by 1960	% total land used for agric by 1998	Rainfall (mm)
I	7 000	1.8	1.6	>1000
II	58 600	15.4	18.8	750-1000
III	72 900	18.0	17.6	650-800
IV	147 800	37.4	33.0	450-650
V	104 400	26.9	29.0	<450

Source: Surveyor-General (1998)

Table 4: Farm sizes from 1980 to 2004

Farm Class	1980		1996		2004	
	Number of farms	Hectares (million)	Number of farms	Hectares (million)	Number of farms	Hectares (million)
Smallholder	700 000	14.4	1 000 000	16.4	1 312 866	24.34
Small to Medium Scale Commercial	8 000	1.4	8 000	1.4	21 000	2.83
Large-scale Commercial	6 000	15.5	4 500	7.7	4 317	3
Corporate Estates			960	2.04	960	2.04

Source: Moyo (2006)

[10] The sites selected for this study are under the smallholder communal farming system and are not part of the commercial farming system which has been transformed by the land reform

The geographical location of Lupane

Lupane is a district in Matabeleland North province in western Zimbabwe (Figures 1 and 2). The province borders the provinces of Midlands and Mashonaland West to the east and northeast respectively, and the province of Matabeleland South and the city of Bulawayo to the south. Matabeleland North province has an area of 75 025 km² and a population of approximately 700 000 (2002 Census). Lupane district lies at an altitude of 976m on the road from Bulawayo to Hwange. In Lupane district, Daluka and Menyezwa wards were selected for the study (see section 4.2.3 for sampling procedures). These two wards are within a radius of 25 km from Lupane Centre. The villages selected for the baseline survey have households mostly found along the Bubi River, which is a tributary of the Shangani River.

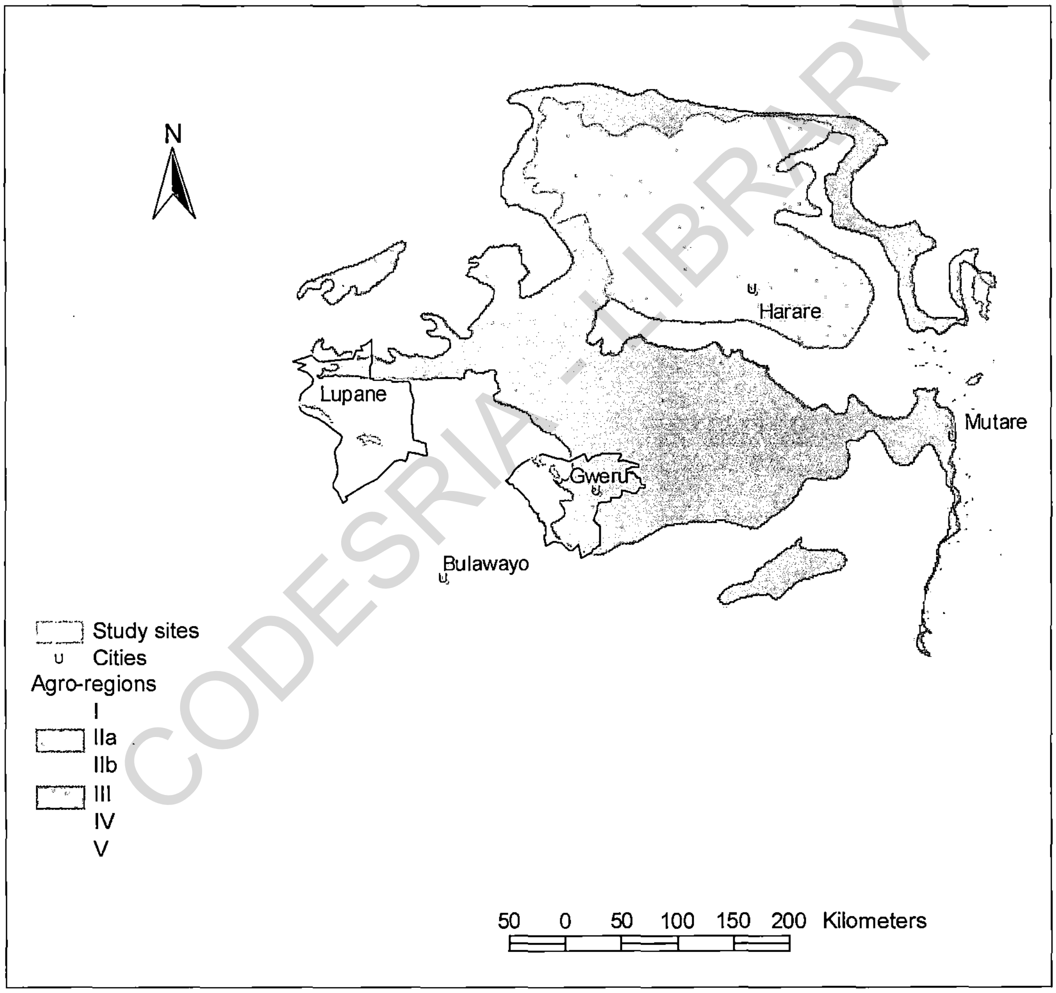


Figure 2: A map showing agro-ecological zones in Zimbabwe and the research sites

The physical environment of Lupane

Matabeleland North province experiences low rainfall and the soils are of poor quality. The province largely falls in regions IV and V. Due to poor soil fertility and limited rainfall, commercial crop production is non-existent. Cattle ranching have proved to be more successful than growing crops in the province. Although Lupane is classified under both agro-ecological regions III and IV, it has more land in Natural Region (NR) IV. Region IV covers much of the west and southern parts of the country especially Matabeleland North and South and Masvingo Provinces. Average annual rainfall ranges from 450-650 mm with periodic dry spells during the rainy season. Farmers in this district frequently experience periods of dry spells, and drought conditions are not uncommon (FAO, 2007). Soils in Lupane, are generally dominated by the Kalahari sands, and are extremely sandy (ACT International, 2003). More specifically, the two selected wards have contrasting soils, with Daluka characterised by black clays, and along Lupane River, whereas Menyezwa is characterised by Kalahari sands. However, in Daluka, there are some households that are upland where the soils are sandy and where most of the land is fallow and used for livestock grazing.

The population profile of Lupane

Lupane District has 26 wards with a total population of 159 662 (ACT International, 2004). By 2006, Lupane was documented as having 160 000 inhabitants. The language spoken in this district is predominantly Ndebele[11]. A survey done in Lupane wards in 2009 indicated that the average size of households is 8 and that 57% of households are women headed, emphasising the large burden of care that women have to contend with, trying to provide on a daily basis for large numbers of children (ACT International, 2004).

Inadequate financing, low enrolment and erratic attendance at school have led to increased cases of teenage pregnancies in Lupane. This was compounded by the lack of supervision resulting from the schools closure of 2008, resulting from disturbances caused by election violence and the subsequent abscondment by teachers. In addition, teenagers were roped in to providing labour for the family in the fields or herding livestock, following the departure of youths to the diaspora in search of jobs.

High rates of HIV/AIDS infection is one of the challenges faced by the inhabitants in Lupane. Local health centres in the District report that more people are testing positive for HIV/AIDS than in previous years and that the infection rate for girls is more than twice that for boys,

[11] The Ndebele emigrated from South Africa and arrived in present day Zimbabwe with the powerful military organisation developed by the Zulu of the Shaka legacy. The Ndebele were able to conduct occasional raids deep into the Shona country, collecting women and cattle from defeated peoples (Bourdillon, 1987 and Beach, 1973 & 1971).

further highlighting higher levels of vulnerability for females (ACT International, 2004). Moreover, residents do not live within walking distance, or within any kind of easy reach of a health care centre, a situation that is detrimental to the chronically ill, who are unlikely to be able to walk or travel far. Shortage of drugs and the poor quality of service in the health centres also compounds the situation for Lupane district. In spite of government policy of free health, health care has not been free in many health centres. Many services supposedly available for free or at minimal cost are not available at government hospitals and have to be sourced through the private sector at huge expense (Solidarity Peace Trust, 2009).

The socio-economic environment of Lupane

There is a diversity of NGO activity in the area working on programmes that include Conservation Farming (CF), seed and livestock distribution and nutrition gardening. These NGOs include Dabane, Christian Care, Catholic Relief Services (CRS) and Help Age. However, these efforts have limited reach as statistics show that about 70% of the farmers in the province have to acquire their own agricultural inputs (FAO, 2007). The two selected wards had had some NGO influence before, but Menyezwa ward at this time did not have any NGO activity with regards to agricultural support. They were only receiving Food Aid from World Vision. Christian Care was operating in Daluka, implementing Conservation Farming (CF) projects.

In addition, Lupane is vulnerable to food insecurity year after year. This district has been declared one of the high food insecurity districts in Zimbabwe. Historically, food insecurity in the country disproportionately affects households in the rural areas of Matabeleland North, with 24% of households in the country found in this province (FAO, 2007). In the district of Lupane there was virtually no harvest at all in 2002. Furthermore, for the majority of people in this district, there were few off-farm activities that people engaged in for alternative income sources (ACT International, 2003). The ZimVAC report of January 2009 further showed that Matabeleland North, with 45% of food insecure families was the second most food insecure province in Zimbabwe, after Manicaland at 47% (Solidarity Peace Trust, 2009).

Livestock is the backbone of the economy in this semi-arid zone and livelihoods are earned from a combination of crop and livestock farming (see Figures 3 and 4 on livestock ownership). While livestock are generally in good condition throughout the province at most times, there is a shortage of dipping chemicals, which results in poor control of ticks and tick-borne diseases. Vaccines and antibiotics are either not available or prohibitively expensive in most cases. For instance, following an outbreak of anthrax in Lupane in 2008, at least six people and more than 200 cattle died. The outbreak was, therefore, a major setback for Lupane farmers. Moreover, food insecurity around the same time led to widespread bartering of livestock in Lupane as families battled to feed themselves. It was often people from outside the villages, or businessmen, who came in and dictated prices at which they would buy cattle, as most rural villagers were equally hungry and desperate by the end of 2008 (Solidarity Peace Trust, 2009).

Matabeleland North province is the main producer of pearl millet in the county. This area is less well suited to maize although many small-scale farmers still plant maize, in addition to planting millet and sorghum (see Figure 5 for the crops grown). Farmers prefer maize to millet and sorghum, because the latter two crops require much more processing after harvesting (pounding), and because birds are more likely to eat them (Patt, 2001). Household food production throughout the province is generally characterised as "poor" or "near-total loss".

In near-normal years, about seven months of domestic consumption is met from own production for Lupane households. However, for the past three seasons, production has been meeting up to two months of consumption demand for most households (FAO, 2007). In a few cases, the district does have high yields. A case in point is the 2005/2006 agricultural season, which was generally good, largely due to high rainfall patterns above annual average. Farmers registered good yields for maize, millet and cowpeas. In the same season, maize did very well in Lupane district. In the 2005/2006 season, Lupane district received 1099mm of rain in contrast to the usual range of 450 to 600 mm (Dabane Trust, 2006).

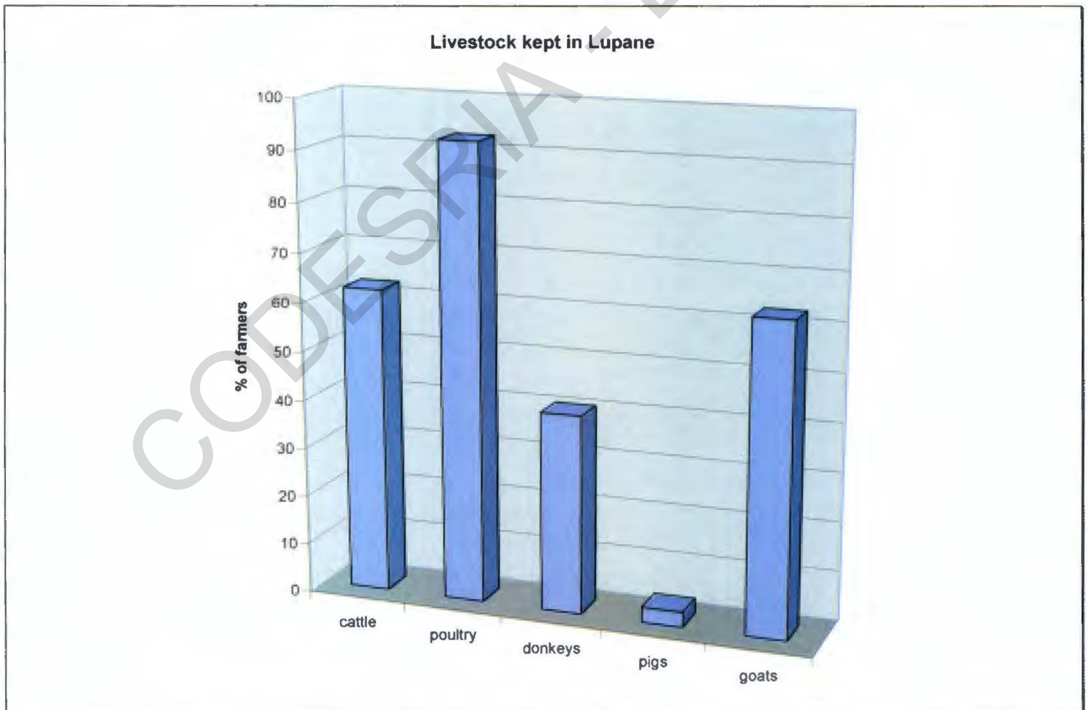


Figure 3: The type of livestock kept in Lupane

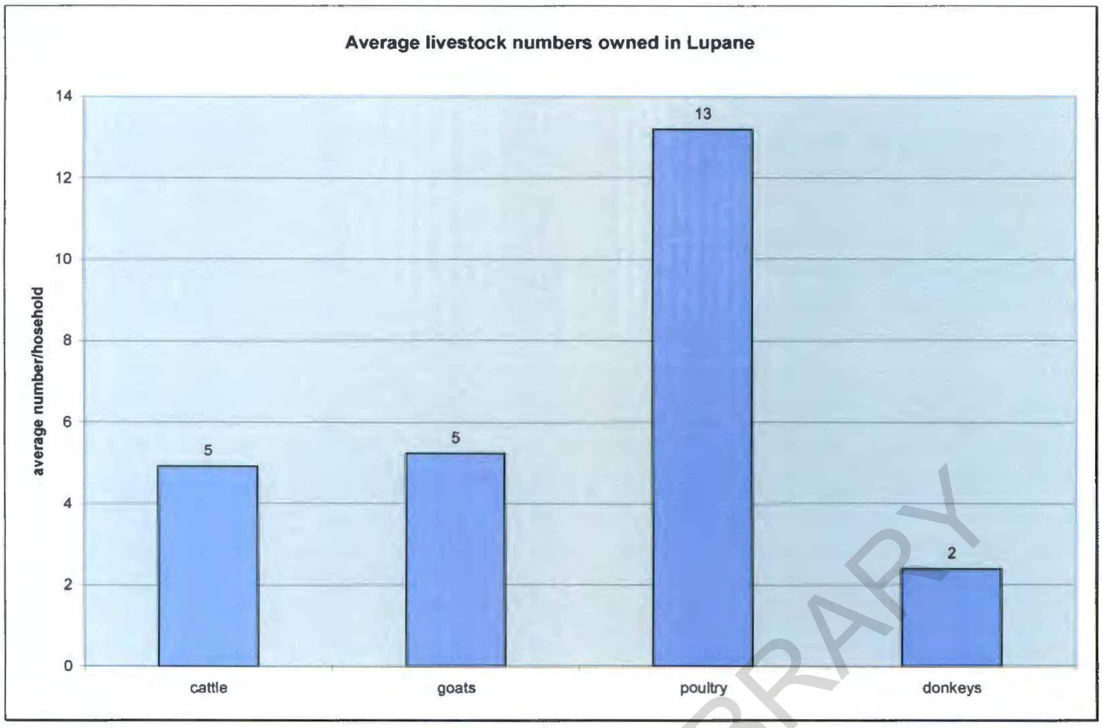


Figure 4: Average livestock numbers owned per household in Lupane

Source: Household survey, 2008

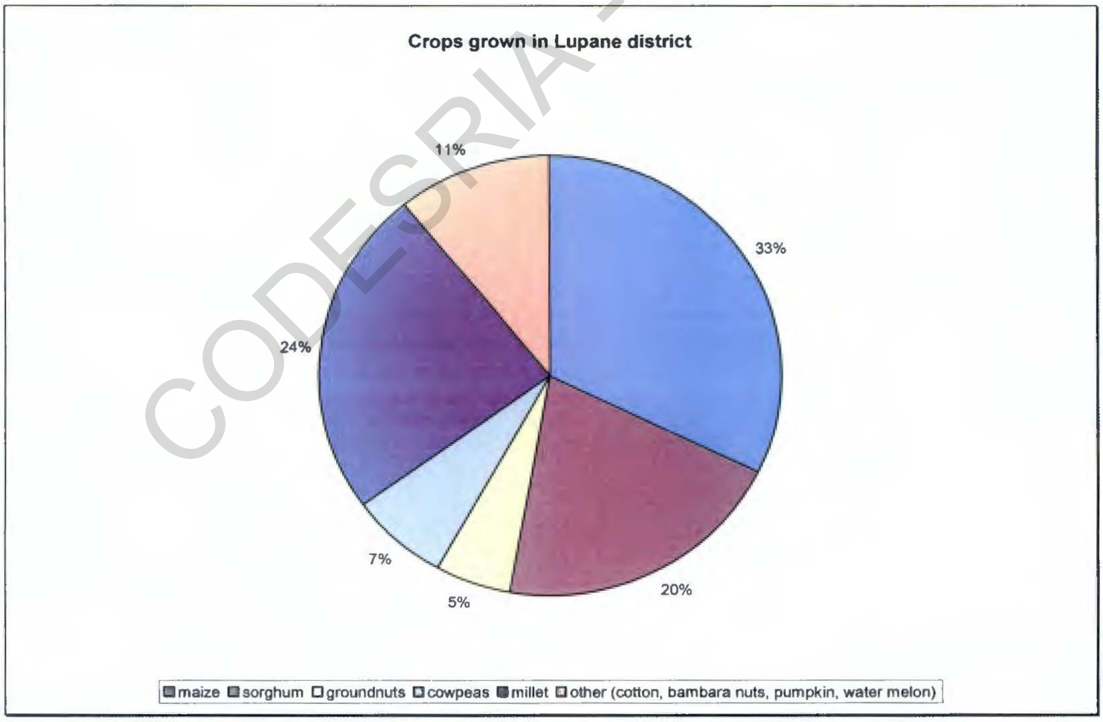


Figure 5: Crops grown in Lupane

Source: Household survey, 2008

In Daluka, farmers have nutrition gardens along the river. Menyezwa ward on the other hand is dry and farmers experience water shortages since their water sources are limited. Drought tolerant crops such as pearl millet and sorghum do better in the area. Water shortages prevent engagement in gardening. Only 40% of households produce vegetables through gardening. The main crops grown by Daluka and Menyezwa are maize and pearl millet.

This vulnerability of Lupane district to food insecurity is further heightened by the lack of adequate water and sanitation infrastructure which is considered to be acute in the province as a whole. In 2003, the Government of Zimbabwe called for assistance in the development of infrastructure such as pit latrines, new boreholes and rehabilitation of old boreholes that were no longer functioning (GoZ, 2003 *cited* in Dabane Trust, 2006). In districts where families have been systematically migrating for generations, those family members who have left the country appear to manage well and remit reasonable amounts to their families. Sadly, this is untrue in Lupane district, where migration is a recent phenomenon and where studies have shown that those who migrate are often unable to improve, or even maintain in any meaningful way, the lives of their families back home. In Lupane, 55% of the households reported having at least one family member in neighbouring countries and abroad, with the greatest proportion of them being in South Africa (Solidarity Peace Trust, 2009).

The geographical location of Lower Gweru

Lower Gweru, communal lands that are located in rural Gweru in the Midlands province, are in agro-ecological region III. A large proportion of region III lies in the Midlands and Mashonaland West provinces. Gweru, 19°25′S 29°50′E19.417°S 29.833°E, is a city in central Zimbabwe and is the capital of Midlands Province. Lower Gweru is a developed communal settlement which is located about 40km north-west of Gweru and stretches a further 50km to the west. Chiefdoms in Lower Gweru include Sogwala, Sikombingo, Bunina and Mkoba. The settlement type in Lower Gweru is well planned and is mostly linear along roads, although it is dispersed in some remote areas. In Lower Gweru, there are several business centres which include Maboleni and Insukamini, a former district administration centre which is also one of the few state townships in the country. The selected wards, Nyama and Mdubiwa, are located in the Maboleni area.

The physical environment of Lower Gweru

While Lower Gweru district is classified under both agro-ecological regions III and IV, the bulk of the district falls under NR III (see Figure 1). Annual rainfall for this region ranges from 650-800mm mostly in the form of infrequent heavy storms. Rainfall is received between November and April. The mean temperature is 16°C with mean maximum and minimum temperatures of 24°C and 10.7°C respectively. Severe mid-season dry spells are common and as a result good farm management is required to retain moisture during the growing season (Drimie & Gandure, 2005). Most of the areas are well watered and marshy. The major river is Vungu, which is a tributary of the Shangani River. The soils in Lower Gweru are predominantly sandy loams but soils in Nyama ward vary from clay to sandy soils and the terrain is predominantly flat. Nyama ward can be considered as a favourable locality with the prevalence of wetlands. In addition, the ward has a high water table. However, Mdubiwa ward is rather dry, with an undulating terrain and sandy soils. The water table is deep and there are no signs of inundation.

The population profile of Lower Gweru

Gweru has a population of about 300 000 (2002 Census), making it the third largest city in the country. Gweru is the capital of Midlands province and achieved city status in 1971. As Gweru falls between the Shona[12] and Ndebele regions, a sizeable percentage of the population can speak both of the major local languages although Shona is spoken by the greater proportion with approximately 30% speaking Ndebele. However, for Lower Gweru, the principal language is Ndebele and is understood by virtually the whole population.

The socio-economic environment of Lower Gweru

Land use in Lower Gweru is typical of communal lands in Zimbabwe with dry land crop production in the rainy season and animal rearing throughout the year. The main crops grown in the area are maize, groundnuts and Bambara nuts (Mugabe *et al.*, 2009), (also see Figure 6). Lower Gweru is one of the districts in Zimbabwe considered to be least food insecure (Mugabe *et al.,* 2009). For instance, the vulnerability assessment of 2003 following the 2002/03 drought portrayed Gweru District as one of the least food insecure districts (ZimVAC, 2003). Farmers often have adequate water for domestic use and agriculture production throughout the year. While farmers also have seasonal dryland fields, wetlands in Nyama ward enable farmers to grow horticultural crops throughout the year. Market gardening, which is predominantly done in the wetlands, is the main economic activity in Lower Gweru. ORAP, Red Cross and Christian Care are working within the area with irrigation drip kits and Treadle Pumps. These drip kits are used in these wetland gardens, which have turned into a commercial activity for local farmers.

[12] It is not clear where the term Shona originated from but according to Bourdillon (1987;16), 'it appears to have been first used by the Ndebele as a derogatory name for the people that they had defeated, particularly the Rozvi, now referred to as the Karanga. The Karanga is also the dialect spoken in Masvingo province, including the study site. The term Shona is used to refer to people who speak different dialects that include Karanga, Manyika, Zezuru, Korekore and others.'

Farmers from Nyama ward supply the Gweru urban district market with vegetables and fruits such as mangoes and guavas. In Mdubiwa, farmers have dryland fields and there are two irrigation schemes. Unlike, Nyama ward, wetland cultivation in Mdubiwa ward is not common. Less than 20% of these farmers are part of the irrigation schemes found in the area, an example being Shagari Irrigation Scheme. These irrigation schemes are different from the wetland gardening that Nyama farmers engage in and the schemes are located in areas set aside specifically for that. The market for the farmers' products is also in the urban part of Gweru district (Mugabe *et al.*, 2009). Some of the villagers also engage in gold panning and other informal work, especially those that are not beneficiaries of the irrigation schemes. Red Cross has only just started working with farmers, mainly giving out farm inputs like seed and fertilizers. However, previous studies conducted in this district have indicated that dry land agriculture contributes about five times more income than wetland garden irrigation and irrigation schemes. The contribution of gardening (mainly conducted as wetland cultivation) to household income is low as compared to dry land cultivation. The hyper-inflationary environment was also cited as affecting the income of these farmers (Mugabe, 2006; Mugabe *et al.*, 2009).

As illustrated in Figures 7 and 8, farmers in Lower Gweru also engage in livestock rearing as a form of livelihood, although the level is much lower than that of Lupane district, which heavily depends on livestock rearing.

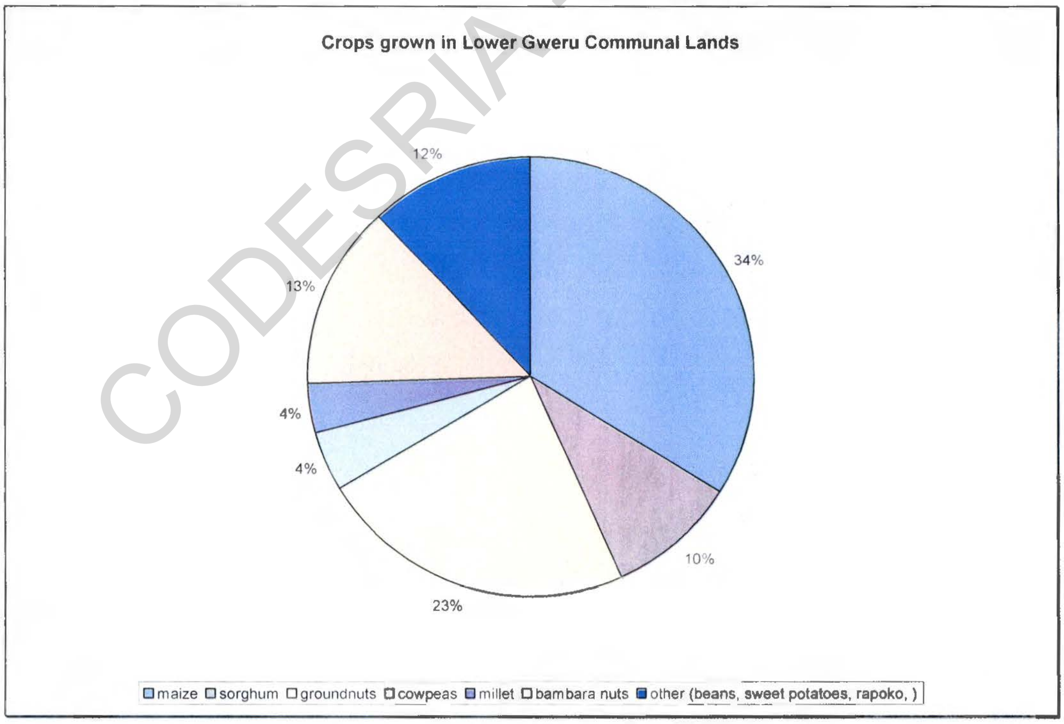


Figure 6: Crops grown in Lower Gweru

Source: Household survey, 2008

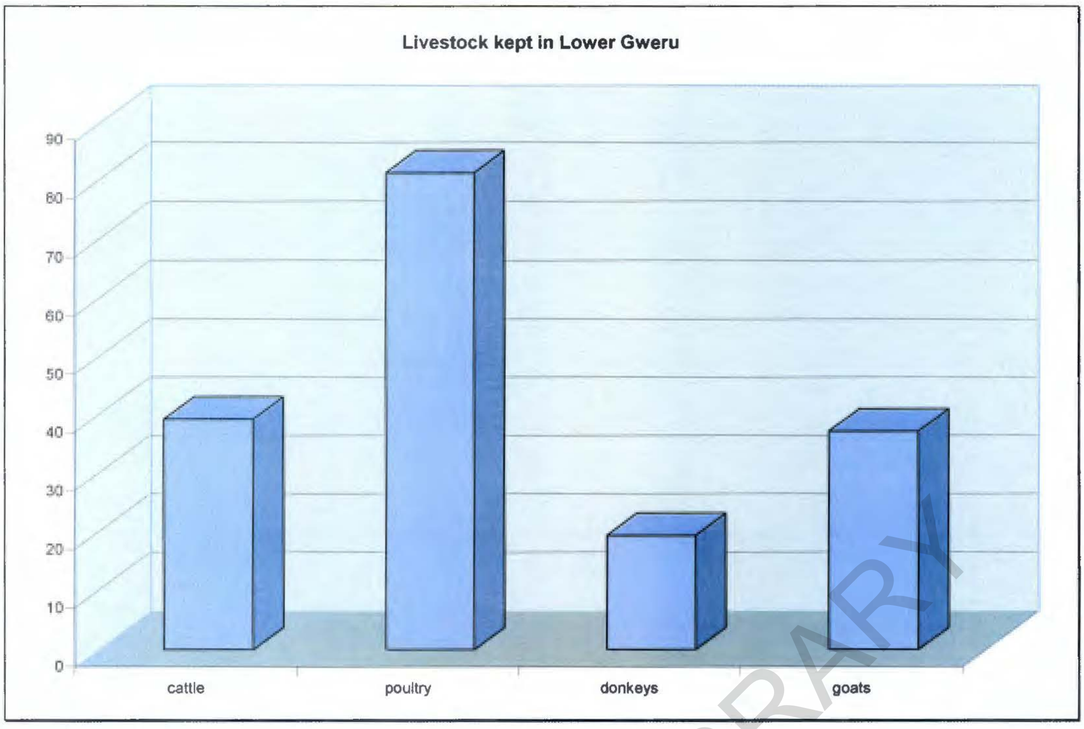


Figure 7: Livestock kept in Lower Gweru
Source: Household survey, 2008

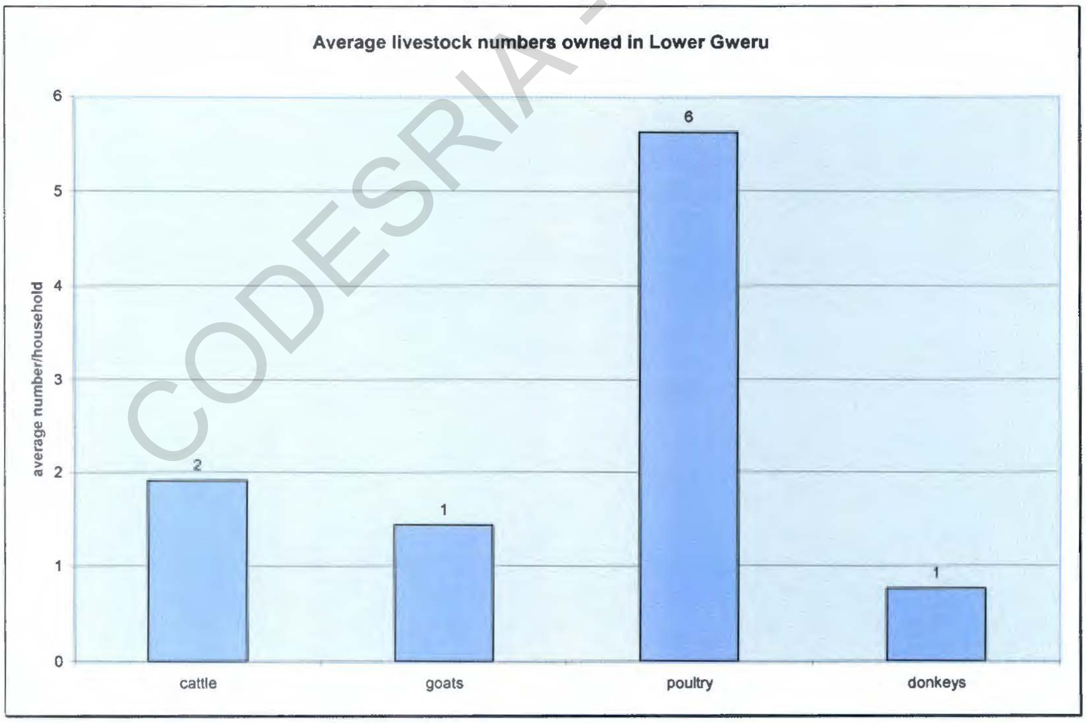


Figure 8: Average livestock owned per household in L. Gweru
Source: Household survey, 2008

4.2.2 BACKGROUND INFORMATION ON STUDY SITES IN ZAMBIA

Zambia has a land area of 752 615 km^2 and lies between 22° to 34° east of the Greenwich Meridian and 8° to 18° south of the equator. Zambia borders the Democratic Republic of Congo (DRC) (Kinshasa) in the north, Tanzania in the northeast, Malawi and Mozambique in the east, Zimbabwe, Botswana and Namibia in the south and Angola in the west (Aregheore, 2009 and Zhu *et al.,* 2008). The country consists mostly of plateau with an elevation between 950 m to 1500 m above sea level. It has a sub-tropical climate and vegetation. There are three distinct seasons: a warm wet season stretching from November through April during which 95% of the annual precipitation falls, a cool dry winter season from May to July with the mean temperature varying between 15°C and 27°C, and a hot dry season prevailing from August to October with an average maximum temperature of 27°C to 32°C. The annual rainfall varies from over 1 200 mm in the north to about 700mm in the central part of the country and less than 700 mm in the south (Jain, 2006).

Zambia is divided into nine provinces, which are further divided into 72 districts. About 60% of the population is concentrated in four provinces: Southern, Central, Lusaka and the Copperbelt. The country has three agro-ecological zones with rainfall as the dominant distinguishing climatic factor. Zone I, which lies in the western and southern part of the country, accounts for about 15% of the total land area. It receives less than 800 mm of rain annually (Aregheore, 2009 and Jain, 2006). Zone II covers the central part of the country, extending from the east through to the west. This is the most populous zone with over 4 million inhabitants and has the highest agricultural potential. The soils here are fertile. Zone II receives about 800–1 000 mm of rainfall annually and this is evenly distributed throughout the crop growing season. Zone III spans the northern part of the country and has a population of over 3.5 million. It receives over 1 000 mm of rainfall annually. The high rainfall in this region has resulted in the soils becoming leached. Zone III is suitable for late maturing varieties of crop. About 65% of the region in this zone has yet to be exploited.

The selected districts of Monze and Sinazongwe are both located in the Southern province (see Figure 9). Sinazongwe lies in agro-ecological Zone I and Monze in agro-ecological Zone II. Southern Zambia covers a total surface area of 85 283 km2 and is the most important cattle rearing area of the country. The province accounts for the largest proportion (24.4%) of cattle-raising households in Zambia (Central Statistical Office 2000). It holds 742 524 head of cattle (28.3% of the country's total cattle population) (NALEIC Zambia, 2002). However, cattle productivity in the area is threatened by cattle diseases such as East Coast fever (ECF), foot-and mouth disease (FMD) and anthrax (Fandamu *et al.,* 2006).

Location of Sinazongwe

Sinazongwe District is bounded on the northeast by Gwembe District, on the northwest by Choma District, on the Southwest by Kalomo District and on the east by the Zimbabwe – Zambia boarder along Lake Kariba. The district covers 4 964 km^2. Most of Sinazongwe lies in the Zambezi rift valley with a hilly terrain and encompasses the upper half of the Lake Kariba shore (ZRCS, 2003). The camps[13] selected for this study are Sinazeze and Sinamalima.

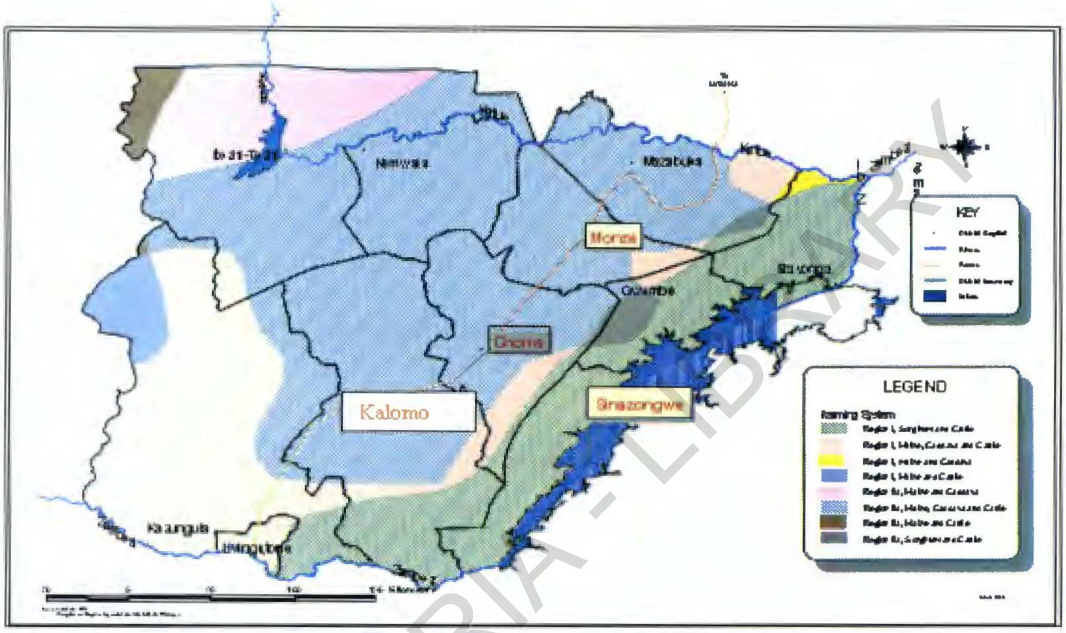


Figure 9: Location of the study districts in Zambia

The physical environment of Sinazongwe

Sinazongwe lays in agro-ecological zone I. For the last 20 years, this zone has been experiencing low, unpredictable and poorly distributed rainfall yet it used to be considered the bread basket of the nation. Much of Sinazongwe experiences semi-arid climatic conditions because of the relatively lower altitude than the plateau area. Temperatures are usually high for most part of the year with annual average temperature around 26°C with minimum temperatures in June/July around 15°C. Rainfall pattern follows an uneven distribution and is generally insufficient with 70% probability of drought. Some rivers and all the streams drain from the Zambezi escarpment. Along the side of these rivers and streams are rich flood plains of alluvial soils, which are cultivated by the local people. Sinazongwe is characterised by hot, dry spells, a short rainy season of 60 to 90 days and an average annual rainfall of 600 to 700 mm (Ziervogel *et al.*, 2008 and ZRCS, 2003). Observed meteorological data suggests that it

[13] Camps in Zambia are similar to wards in Zimbabwe

is currently the driest zone in Zambia, very prone to drought and has limited potential for crop production (Zhu *et al.*, 2008).

Woodlands with dominant Mopane *Colophosphermum Mopane* tree species cover the District. The trees do not form thick forests, but are scattered. Due to low rainfall, grass is very short throughout the District except in pockets of alluvial soils in the flood plains. Soils in Sinazongwe district are a mixture of well drained, moderately shallow to deep, yellowish red, friable clay soils (chromi-entric CAMBISOLS), and well drained shallow to moderately shallow, dark brown to brown, friable, fine loamy to clay soils (orthi-entric LEPTOSOLS) (de Wit 2006).

The population profile of Sinazongwe

Sinazongwe has a population of 13 387 households and a population density of 13 persons per km^2 and covers an area of 5 195 km^2 (Ziervogerl *et al.*, 2008). It has the lowest total population estimated at 80 375 people living in 13 387 households. The annual population growth rate for the district is below the provincial growth rate and stands at 1.2% (Ziervogerl *et al.*, 2008). However, the growth rates between sexes vary with the female population growing faster than the male population. However, this does not place women in a better position to take part in every day decision making. For instance, traditionally, men control most of the land. They decide on the use of the land while women have limited say over what to do with the land (ZRCS, 2003). Table 5 summarizes the population characteristics of Sinazongwe district.

Table 5: Population characteristics of Sinazongwe district

Households	Males	Females	Total	Males	Female	Total
13,576	39,497	40,958	80,455	49.09%	50.91%	100.00%

Sources: CSO Census Report November, 2002

Traditionally, Sinazongwe is divided into two Chiefdoms, Sinazongwe and Mweemba. The major ethnic grouping in the district is the Tonga and the language spoken is predominantly Tonga.

Although government mostly provides education, there are also a number of community supported schools in Sinazongwe. However, staffing in most of the schools is inadequate, especially in the remotest schools where only one or two teachers run some of these schools. Moreover, there is inadequate infrastructure in 13 out of the 40 schools in the district. These schools are in need of rehabilitation. Classroom accommodation has been inadequate in most of the schools and some do not have enough toilets. In extreme cases, toilets are not available. This is compounded by the fact that many of the schools are quite far apart and pupils are forced to walk long distances (ZCRS, 2003).

Sinazongwe District Health Management Board (DHMB) manages the health care services in the District with support from other stakeholders including NGOs. The Board operates 12 rural health centres (RHC), one in each ward of the District and one referral Hospital at Maamba. Malaria has been declared the number one killer disease in the district. While Sinazongwe district boasts of the only coal mine in the country, the operational viability of this mine is threatened by inadequate production equipment, working capital and has huge company liabilities. In addition, HIV/AIDS is also decimating the workforce. High rates of STIs reported from health institutions are an indicator that this could be the same with HIV/AIDS (ZRCS, 2003).

The socio-economic environment of Sinazongwe

The district is characterised by poor seed availability, poor marketing facilities and poor infrastructure. Due to these constraints, risk to food insecurity in Sinazongwe is high. Villagers in this area have been also affected by social and historical events like the construction of the Kariba dam (Ziervogerl *et al.*, 2008). The flooding of the lake reduced the area available for recessional winter agriculture. There are two main forms of land tenure in the District, which are trust and traditional land tenure systems. The former is state land under the control of the President through the Commissioner of Lands, leased to various establishments and the latter is the dominant system in the district where Chiefs allocate occupancy and use rights (Ziervogerl *et al.*, 2008). However, since all land is vested in the President, this land can still be converted to state land through consultations with the Chiefs (ZRCS, 2003). The district is generally a food deficit area because of low productivity. This is mostly attributed to somewhat low annual rainfall, poor soil fertility, high input costs, transport costs, low usage of drought tolerant crop varieties, cattle diseases, inadequate extension services and poor infrastructure (Ziervogel *et al.,* 2008 and ZRCS, 2003).

Agriculture and fisheries are the basis of livelihoods and the economy of the Tonga people in Sinazongwe district. The major crops grown in Sinazeze and Sinamalima are maize, cotton and sorghum (see Figure 10). However, due to displacement of the Tonga people by the lake, they now live and cultivate on marginal infertile land on the edges of the valley. Significant to agricultural activities in Sinazongwe is livestock rearing (see Figures 11 and 12 for livestock kept in Sinazeze and Sinamalima). All livestock kept in the district is under the traditional sector with very minimal conventional interventions such as dipping, de-worming and vaccinations. This sector has been greatly marginalised by agriculture related extention services despite the fact that it is the economic backbone of the majority of the population due to constant poor crop yields because of the unfavourable rain pattern. The severe and widespread loss of cattle, including work oxen, caused by the "corridor disease" also contributed to loss of income for farmers.

The district suffered three consecutive years (between 2002 and 2005) of poor rainfall leading to a severe food insecurity situation, which prompted people to dispose of valuable assets and sell livestock at under their value in order to obtain food (ZRCS, 2003). Sinazongwe District Disaster Management Committee (DDMC) (2005) has indicated that in the seasons between 2002 and 2005, on average, 75% crop failure was experienced in most parts of the district and that camps to the southern end of the District were the worst affected due to low rainfall recorded (see Table 6) . Estimates showed that the amount of food being sought was 942.84 metric tones per month for 17 460 households (78 570 people) targeted yet they received only 421 metric tons food for May 2005, September 2005, November 2005, April 2006 and May 2006 from DMMU-OVP.

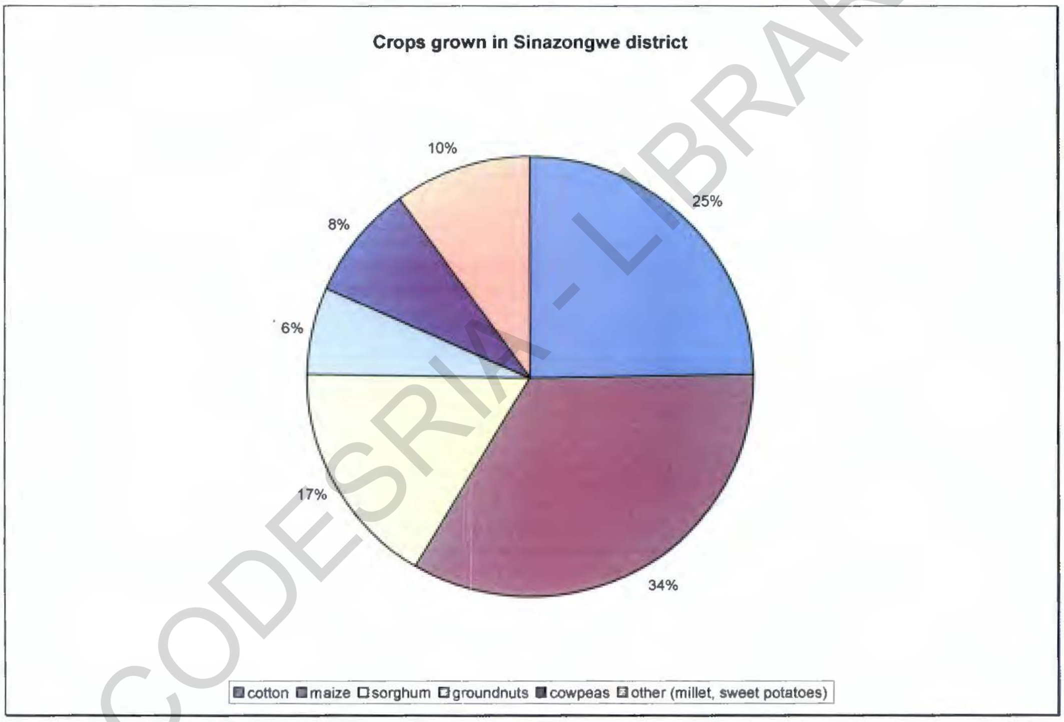


Figure 10: Crops grown in Sinazongwe

Source: Household survey, 2008

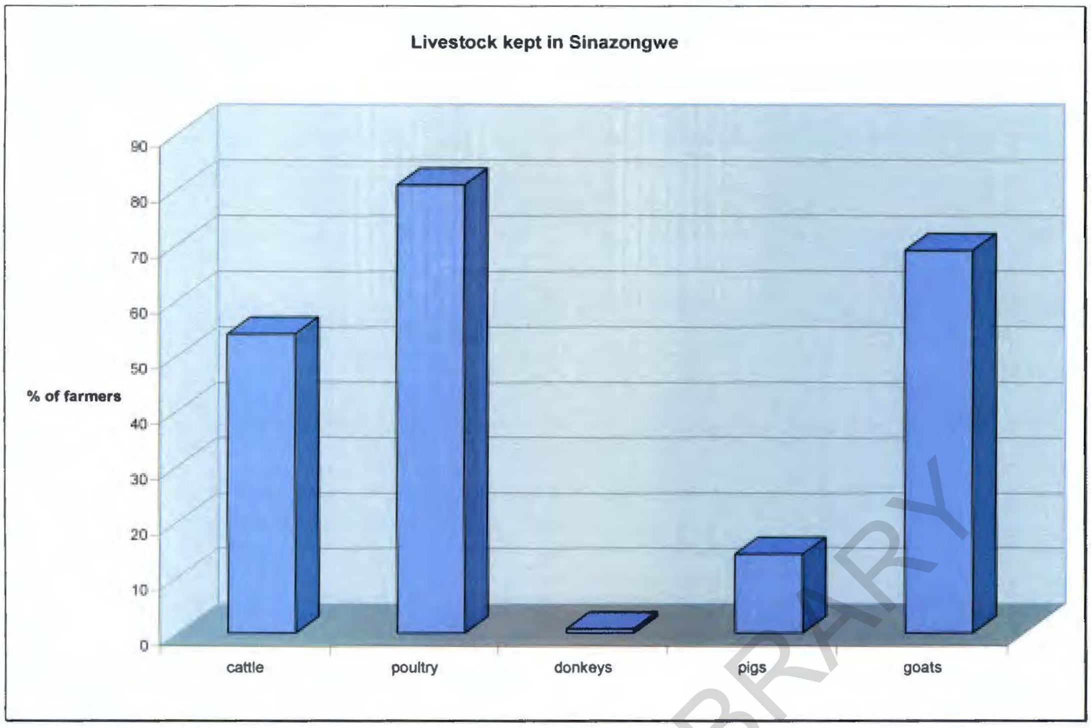


Figure 11: Livestock kept in Sinazongwe

Source: Household survey, 2008

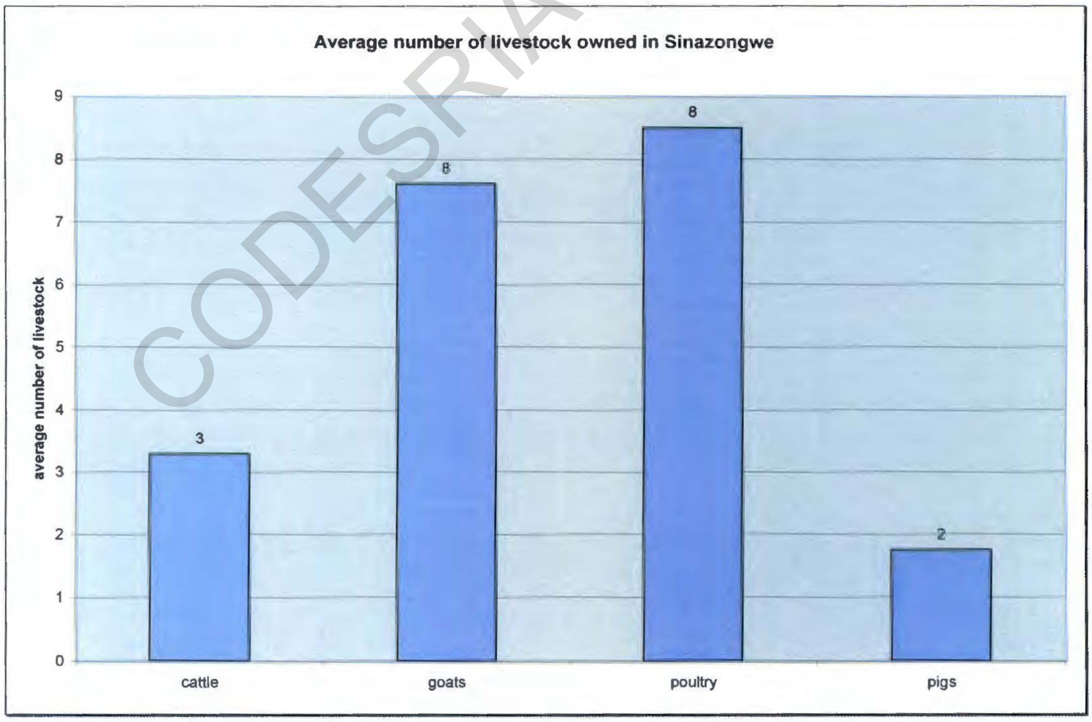


Figure 12: Average livestock owned per household in Sinazongwe

Source: Household survey, 2008

The situation in the district is that food is only abundant for a short period between 3 to 5 months. The rest of the months people struggle to meet consumption needs, as there is inadequate knowledge in soil and water conservation measures (ZRCS, 2003). While droughts and poor rains have been implicated in contributing to food insecurity, flash floods have also been cited as a cause for concern.

Table 6: Rainfall amounts received in Sinazongwe between 2002 and 2005

Season	Month & Rainfall amount (mm)					
	Oct	Nov	Dec	Jan	Feb	Mar
2002/2003	9.0	44.7	48.0	31.7	99.3	196.8
2003/2004	35.1	85.1	118.1	139.0	180.5	245.4
2004/2005	2.5	13.4	100.6	104.4	29.4	22.9

Source: Ministry of Agriculture and Co-operatives (MACO) Sinazongwe District (2005)

In the open forests, farmers exploit a lot of wild fruits such as Mabuyu and Busiika, which they also easily exploit for the processing of local drinks. Other exploitable forest products include timber, honey and herbs for medicine (ZRCS, 2003).

Sinazeze has developed into a sub-centre of Sinazongwe through providing services such as accommodation, drinks and meals to travellers. While there is ample public transport in the district, there is need to improve on road structures, particularly the un-gazetted roads that have been neglected for many years. Tarred roads lead to many of the service centres and to the coalmine. Electricity is only available in central places such as Sinazeze, Buleya Malima, Buchi, Sinazongwe Boma, Maamba and Mweemba/Kanchindu. In addition, despite having abundant water reserves from Lake Kariba, there are inadequate safe water points throughout the district and no facilities to utilize the water for irrigation development. Due to poor rainfall, constructed dams and weirs dry up for some part of the year.

The geographical location of Monze

Monze district is located about 180km south-west of Lusaka. The administrative centre for this district is Monze Town. The camps selected for this study in Monze are Mujika and Njoola.

The physical environment

Monze lies in agro-ecological region II, with an average annual rainfall of between 800 and 840 mm and a moderate temperature environment (Ziervogel *et al.*, 2008). Farmers in the Monze District have recognised a general reduction in the length of the growing season and shifts in the onset of the season. Main soil groups are Luvisols, Vertisols and Acrisols and have low to medium water holding capacity and poor workability. In addition, there is low soil nutrient retention capacity, high acidity in some pockets and micro-nutrients deficiencies. Most soils in Monze have been cultivated for decades, and the continuous application of chemical fertilizers (especially when agricultural subsidies were available) has rendered them infertile and low-yielding. Deforestation and soil erosion in the district are rated as being high (Ziervogel *et al.,* 2008).

The population profile of Monze

Monze district has a total population of 165 741 people (49.1% for males and 50.9% for females) living in 26 194 households. It has the highest overall population growth rate of 2.2%; 2.3% for males and 1.8% for females (Ziervogel *et al.*, 2008). The main ethnic group in Monze is the Tonga, although immigrants from other Zambian tribes have retired here after working in the area. Marriage, which is either monogamous or polygamous, depends on the husband's willingness and ability to support more than one wife. Traditionally, when the local economy was vibrant and it was easy for people to take up farming, even after completing secondary school, it was prestigious for a man to have more than one wife. At that time wives and children were used as a source of cheap farm labour (FAO, 2003).

At the same time, HIV and AIDS are increasingly negatively affecting the productivity of the district's population, with as many as one in 6.5 households already having experienced illness or a death due to AIDS. Rural areas in Monze and Sinazongwe have higher HIV/AIDS prevalence rates than urban ones (Ziervogel *et al.,* 2008). Monze has a prevalence rate of 14% for the age group 15-49. There is an increasing trend in the number of female-headed households. This is mainly a result of massive declines in the Tonga culture's traditional practices of sexual cleansing and wife inheritance, which are being abandoned in response to the HIV/AIDS pandemic.

There are indications that a large proportion of children in all household types dropped out of school owing to lack of financial support (57%), and that only a small proportion managed to complete their schooling (7%) (FAO, 2003).

The socio-economic environment

Monze district is home to the Tonga speaking people. The main industry in the district is agriculture with maize being the most important crop. Other major crops grown include groundnuts, cowpeas and sweet potatoes (see Figure 13). Monze district is one of the major crop-producing districts in the Southern Province. At one point in the past, the district used to produce more than 25% of the maize crop in Zambia. It was at that time popularly known as the 'home of Zambia's granary' (Zhu *et al.*, 2008:69). Although its status as the leading maize producer has declined over the years, the most prominent feature in the town is still the grain silos to the north of the town. Production constraints in Monze include low levels of extension services, livestock diseases and lack of credit facilities. However, risk of food insecurity is moderate in the district due to relatively developed infrastructure and moderate access to other infrastructure (Zhu *et al.*, 2008). Relief maize is the only hope for subsistence farmers with little or no money, no food in the granary, and no prospect for improvement.

In Monze district, in addition to the drought, there was also a serious epidemic of East Coast fever affecting cattle in 1992, and this resulted in the deaths of a large percentage of the district's herd causing further impoverishment among some of the district's poorer households (Boko et al 2007). At this time, about 2 000 cattle died in Monze due to corridor disease. Though the government in this period released USD4 million to eradicate the disease, the outbreak remained rampant. In adjusting to the drought, the population has had to sell off livestock and their main assets, which has depressed the market value. In addition, 33% of the animals in the southern district have died from corridor disease. Before the outbreak of corridor diseases around 1992, the district had a total cattle population of approximately 300 000. By 2000, the number was estimated at 77 000.

The type of livestock kept and average number of livestock owned per household in Mujika and Njoola camps is highlighted in Figure 14 and 15. While 53% of the households in Monze owned one or more draught animals in 1992, the percentage had dropped significantly to 23% by 1998 among 1 629 households (Dibbits & Mwenya, 1993 and Kaoma-Sprenkels & Mwenda, 1999). This gives an indication of the decline in availability of draught power in the last decade, also suggesting the loss of trained oxen affecting ploughing in this period and beyond. These circumstances have resulted in a decline in crop production in the Southern Province, once with a thriving agricultural economy characterised by wide-spread use of draught animal power (DAP) (Chipungu, 1988).

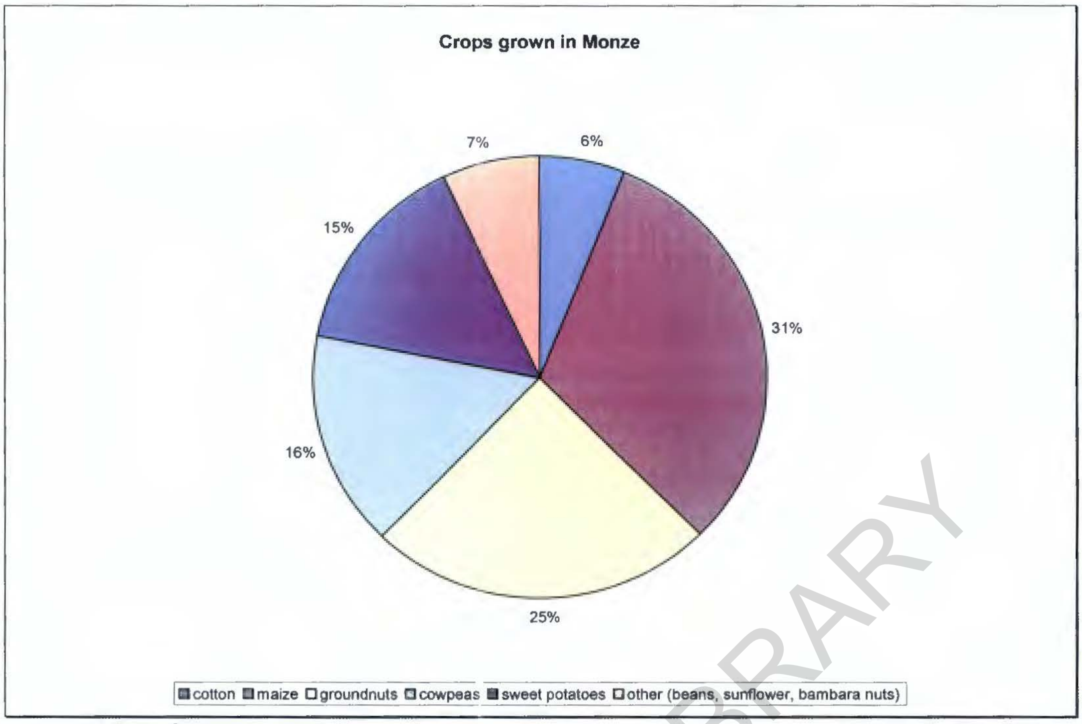


Figure 13: Crops grown in Monze

Source: Household survey, 2008

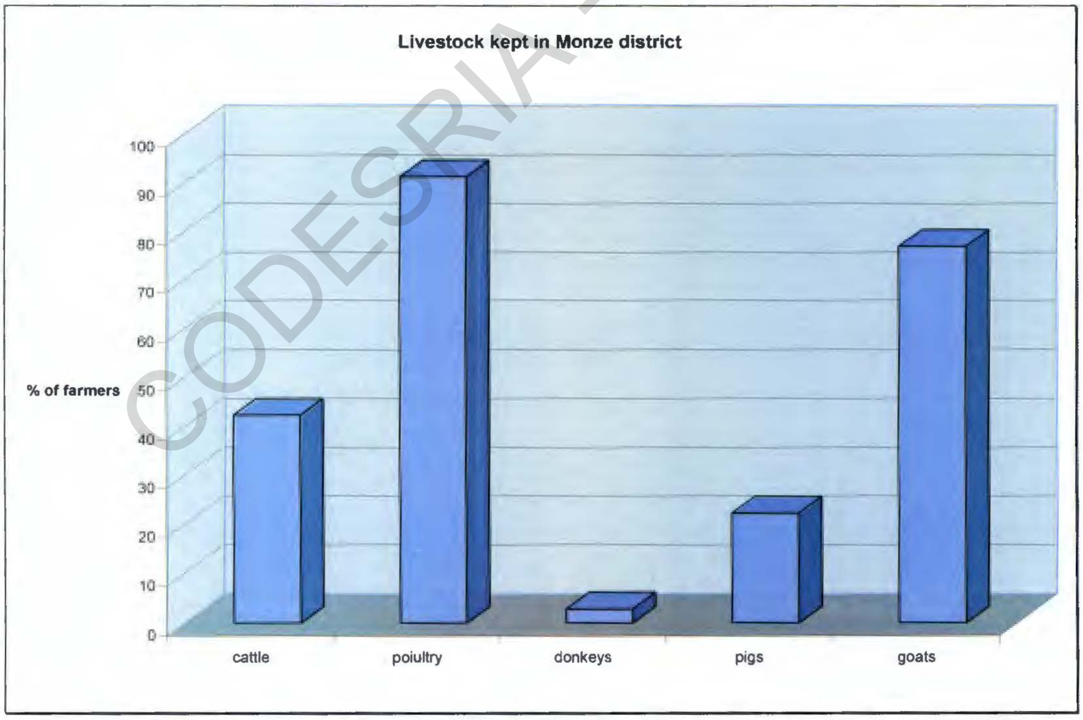


Figure 14: Livestock kept in Monze

Source: Household survey, 2008

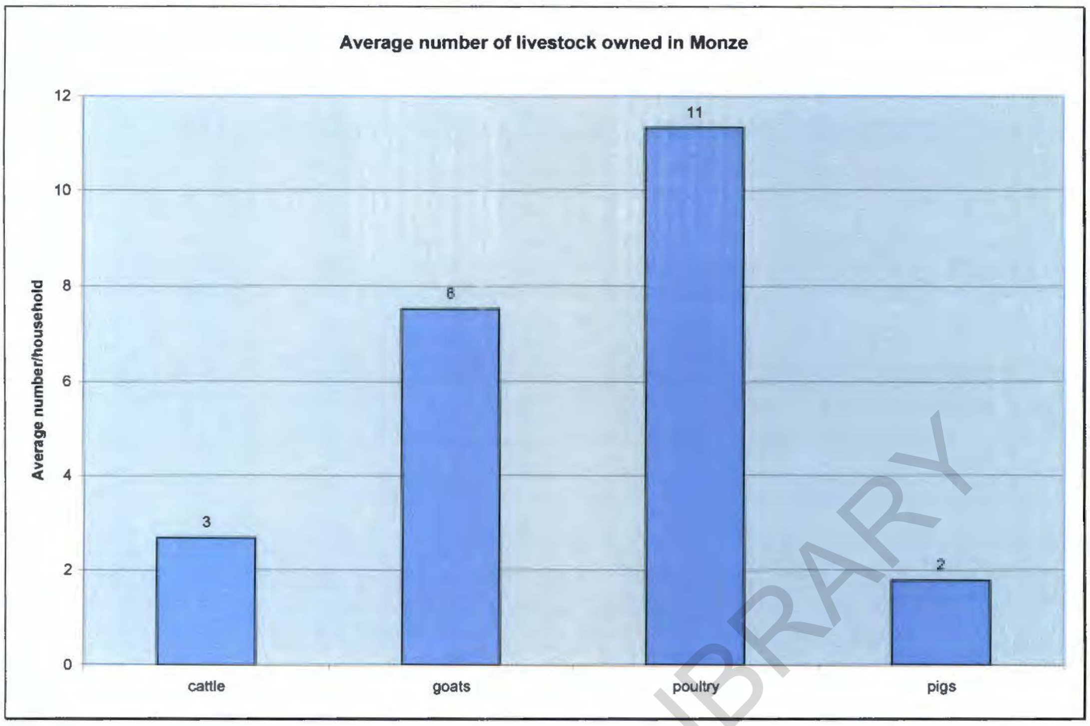


Figure 15: Average livestock owned per household in Monze
Source: Household survey, 2008

4.3 METHODOLOGICAL DESIGN

This study was part of a broader inter-institutional development project. This project was an International Development Research Centre (IDRC) funded initiative led by Midlands State University in Zimbabwe and the Zambian Meteorological Office in Zambia. The project incorporated a socio-economic component based on the perception that there were more studies that concentrated on biophysical and hydrological issues alone, with little emphasis on socio-economic issues. It was, furthermore, based on the premise that improving the ability of institutions that train the 'Future Change Agents', who will subsequently support smallholder communities in adapting their agricultural practices to current climate variability, is the first step in building adaptive capacity to cope with future climate changes. These 'Future Change Agents' include agricultural and meteorological extension service providers and researchers at universities. Zambia and Zimbabwe provide a suitable context for studying climate change adaptation processes by farmers, given the highly variable climate conditions in these two countries.

The aim of the project was to bring together experiences from national and international research and extension institutions that are working in Zimbabwe and Zambia, to build upon simulation models. Participatory on-farm research and climatic forecasting were integral components of the project to increase the competencies of smallholder farmers in coping with current climatic variability and adapting to potential climatic change. A number of doctoral and master's studies were undertaken in the different objectives of the project. This study was modelled around objective two of the project's objectives, namely *to determine how rural communities have coped with climate variability and extremes and develop appropriate strategies for adapting to future climatic change.* Following this broad objective, the following objectives, as highlighted in Chapter One, were formulated for this study:

1. Investigate farmer perceptions of threats from climate variability and change and how these differ across countries,

2. Identify and analyze the impacts of climatic variability and change on farmer households in the two countries and

3. Identify coping and adaptation strategies to climate variability and change by farmers and investigate factors influencing these strategies across Zambia and Zimbabwe

Essentially, the role of this researcher was to take a lead in participatory activities with farmers, within the scope of this study and document findings to inform and suggest recommendations for the project.

4.3.1 RESEARCH METHODOLOGY

The qualitative research methodology formed the basis of this study, although a quantitative research design was also employed. The two approaches are complementary, providing different perspectives and answering different specific questions within any one broad area (RDSU, 2003).

As in this case, social research in a development project context on the dynamics of farmers' adaptation to the vagaries of climate change is complex and, therefore, requires use of methods that ellicit the dynamism of numerous intricate processes of social interaction (Nemarundwe, 2003). In addition, qualitative research is inherently multi-method in design (Denzin & Lincoln, 2000 and Flick, 1998) and this enabled use of triangulation to validate data gathered through the questionnaire survey and other methods. In the same respect, RDSU (2003) state that qualitative research may also help to understand the findings of quantitative research. In this way, the researcher endeavoured to offset the potential biases associated with quantitative research, mainly, such as being subject to researcher bias (RDSU, 2003).

4.3.2 RESEARCH STRATEGY

Fundamental to this study is the use of a case study. Detailed empirical research is needed in a specific geographical context to understand the dynamics of climate change adaptation. A case study approach was adopted in order to produce detailed analyses of farmers' strategies in dealing with vulnerability due to climate variability. The approach is an efficient way of capturing context specific details. A case study is "an empirical enquiry that investigates a contemporary phenomenon within its real-life context" and is particularly suitable for answering the 'how' and 'why' questions (Yin, 2003:110), for instance; How do coping and adaptation strategies differ by country? A case study is also defined as an empirical inquiry that investigates a phenomenon within its real-life context and relies on multiple sources of data (Alexander *et al.,* 2005).

A question that often arises in relation to case studies is their representativeness. The sampled districts in Zimbabwe and Zambia fall under specific agro-ecological zones. If other factors are considered, these districts are not very different from districts in these two countries falling under the same agro-ecological zones. In addition, like similar communal areas in these countries, the sites are generally characterised by infertile soils that are characterised by low productivity and high risk of droughts and crop failure. In this respect, findings from the sampled districts may be applicable to other parts of the same communal areas as well as other communal areas in Zimbabwe and Zambia that have similar characteristics.

4.3.3 SAMPLING

Sampling procedures

A multi-stage sampling technique was used to select the villages and households to be interviewed from Zimbabwe and Zambia, moving from the most general level (country) to the most precise level (household). In the first stage, the two countries were purposefully selected from Southern Africa, based on the fact that research collaborators in the project are based in Zimbabwe and Zambia. In the second stage of the sampling process, four districts were purposefully sampled: Lupane and Lower Gweru in Zimbabwe and Monze and Sinazongwe in Zambia. These were selected on the basis that in each country, one district is wet and the other district is dry. The significance was to enable the research to focus on similarities and differences in impacts from and adaptation to climate variability and change in these contrasting areas.

The third stage involved selection of two wards in each district. One of the criteria for selection was that the areas must be where there is a meteorological station where records of rainfall have been kept for a long period of time. In addition, wards that had two or less activities/projects sponsored by NGOs were targeted as this would also affect the coping strategies used by farmers. In the next stage, three villages were selected through systematic random sampling from an average of eight villages per ward in each country, bringing the total of villages to 12 between the two countries. FGD participants were then picked systematically from each of the three villages per ward as highlighted in the following sections under each relevant data collection method. In the last stage, specifically for the questionnaire survey, systematic random sampling was employed to come up with 30 households per village, bringing the total number of households between Zimbabwe and Zambia to 720 (12 villages x 30 households x two countries). A summary of the distribution of questionnaires in the study sites is presented in Table 7.

Participants for the PRA exercises ranged from eight to 15. Effort was made to have both men and women represented in the different exercises. Moreover, separate PRA workshops were held for men and women in order not to compromise the amount of information that can be generated from the less confident participants if they were to be combined. Specifically, old men and women were incorporated into the sample for the group discussions in order to capture information related to historical trends. It was envisaged that they would be able to recall as far back as they can and provide rich information on trends and indigenous adaptive innovations to climate change. In the same context, youths were part of the sample so as to determine the impact of climate variability on them.

Some of the factors considered in sampling for in-depth case studies include cases where the households in question have successfully coped with the vagaries of climate change or those of individuals that have been struggling, but have still not been able to cope. Their vulnerability context and perceptions to climate change were captured. Also of importance was the need to consider gender in the sampling of the cases. Both men and women, young and elderly were selected so as to be able to understand how experiences differ by gender and age. Moreover, the researcher took into account access to weather information during sampling. Those farmers who were being provided with weather information on the project were sampled to compare with those who did not have the same access.

Table 7: Summary of the study sites and sample size

Country	District	Ward/Camp	Villages	Sample size
Zimbabwe	Lupane	Daluka	Daluka	30
			Gandangula	30
			Mafinyela	30
		Menyezwa	Banda	30
			Masinyane	30
			Menyezwa	30
	L. Gweru	Nyama	Mathonsi	30
			Guduza	30
			Musingondo	30
		Mdubiwa	Madinga	30
			Mxotshwa	30
			Nsukunengi	30
Zambia	Monze	Mujika	Sintambo	30
			Muyamba	30
			Cheepa	30
		Njola	Sikaula	30
			Mweenechepa	30
			Hamoya	30
	Sinazongwe	Sinazeze	Sinazeze	30
			Namukamba	30
			Simapumba	30
		Sinamalima	Sinamalima	30
			Sinakihimbi	30
			Malima	30
Total sample				720

4.3.4 DATA SOURCES AND DATA COLLECTION

The research objectives and broad research questions of the study were used to identify data requirements and suitable data collection methods. The research objectives, questions, data needs and methods used are shown in Table 8. The different data collection methods are described each in detail in the following section.

No single research method can capture all dimensions of a complex research problem; it is, therefore, prudent to combine two or more methods drawing conclusions from a synthesis of the results (Ulin *et al.,* 2002). It has already been highlighted that triangulation of multiple methods was used for this study. Each source provided a reliability check on the other sources, while at the same time providing additional insights about issues, relationships, discourses and practices of farmers. Specific research methods used include participatory rural appraisal exercises, focus group discussions, in-depth case studies, the household survey and secondary data review. Research methods and the levels of analysis used are presented in Table 9, after which a detailed description of the methods follows.

Table 8: Research objectives, questions, data needs and methods used during the research process

Research objective	Research question	Data needs	Data sources and methods of data collection
1. Investigate farmer perceptions of threats from climate variability and change and how these differ across countries	What are farmers' perceptions of risks, their vulnerabilities to these risks and how do the perceptions differ by country?	Risks to farmers' livelihoods -climate risks -non-climate risks Importance/intensity of risks Indicators of vulnerability	Focus Group Discussions (FGDs) (brainstorming) Household survey Matrix scoring and ranking Household survey, resource mapping Role play(The River Code) In-depth case studies
2. To analyze the household and community impacts of climatic variability and change in the two countries	What are the impacts of climate variability and change at household and community levels?	Negative impacts on farmers Positive impacts on farmers	Household survey Participatory impact diagrams FGDs In-depth case studies Trend lines
	What other factors compound the impacts from climate change?	Other factors that have impacts that are similar to climate change	In-depth case studies FGDs
3. Identify the coping and adaptation strategies to climate variability and change by farmers and compare these across Zambia and Zimbabwe	What are the coping and adaptation strategies to climate change by farmers in the face of existing climate variability and how do these strategies differ across countries?	Coping strategies Adaptive strategies Farmers use of adaptation strategies Indicators of resource endowment Social Networks Household characteristics	Household survey FGDs Seasonal and Daily activity calendars by gender Resource mapping Case studies
	What factors influence farmers' adaptive capacity and what are the resources required for them to cope and adapt?	Coping strategies Adaptive strategies Institutions Household characteristics	Household survey FGDs Institutional mapping

Table 9: Methods of data collection used and the levels of analyses

Methods of data collection used	Variable	Sources	Levels of analyses
Resource mapping	Natural resources Physical Access to resources Control of resources Changes in resources Causes of the changes	Village PRA workshops	Village
The river code	Opportunities for livelihoods Constraints to livelihoods and farming systems	Village PRA workshops	Village
Institutional mapping	Formal Institutions in areas informal Institutions in areas Support in climate change issues and livelihoods	Village PRA workshops	Village
Historical trend lines	Climate related major occurrences Political major occurrences Social major occurrences Period events occurred	Village PRA workshops	Village
Participatory impact diagrams	Impacts of major occurrences on livelihood, farming	Village PRA workshops	Village
Daily/seasonal activity calendars	Gender division of labour Activities for men and women by seasons Access and control of resources	Village PRA workshops	Village
Matrix scoring and ranking	Scores and rank for opportunities and constraints Scores and ranks for crops grown and livestock kept	Village PRA workshops	Village
Focus group discussions	Crops grown Livestock kept Livelihood and farming opportunities Livelihood and farming constraints	Village members: men and women (elderly, youths and middle aged)	Village
In-depth case studies	Perceptions of climate change Impacts of climate change Strategies to deal with impacts General household characteristics	Individual men and women from both female- and male-headed households	Household
Questionnaire survey	Household characteristics Perceptions of climate change Impacts Household capital assets and income sources Risk management and vulnerability	Household heads	Household

4.3.5 THE QUANTITATIVE APPROACH

The questionnaire survey

The questionnaire was divided into themes and specific information for each theme was collected. Information collected includes household characteristics, farm characteristics, resource endowment, income sources, food availability, social networks, perceptions of climate change and variability, impacts of climate change and variability, coping and adaptive strategies that households are using, sources of information on climate and weather and changes in production. The various themes and content for the questionnaire are presented in Table 10.

The questionnaires were administered by the researcher with the assistance of extension officers from the particular areas. These extension officers were trained in order to understand the objectives of the study and its importance. Involvement of extension officers was important to help locate the selected households within each extension unit. Another advantage of using these extension officers is that they had experience in questionnaire administration as they often work with other researchers in various other projects linked to the extension department.

4.3.6 THE QUALITATIVE APPROACH

a) Participatory Rural Appraisal

PRA provides a basis for dialogue through which information is shared and through which the researcher can learn from and with the rural people. This method makes use of local knowledge and experience with local people identifying their problems and their needs. The researcher only plays a facilitatory role (Bhandari, 2003 and Wall *et al.,* 2006).

Table 10: Questionnaire themes and the type of information collected

Questionnaire theme	Type of information
1. Agricultural production	Land owned, land cultivated, land not being utilised, priority crops grown, average yields in good and bad years, changes in production in last 5 years, causes of decline in crop production, current improved and local technologies being used
2. Household income and capital assets	Livestock ownership, agricultural implements ownership and domestic assets ownership, main sources of income, training in agricultural production, assessment of ability to carry out climate and agricultural related activities, group membership
3. Farmer perceptions of climate change	Significant changes noted and their causes, impacts of changes at household level and on the environment, actions taken in these changes in agricultural production, access to and kinds of weather information, rating of information received, actions in positive and negative information, traditional/indigenous ways of predicting weather patterns, coping with changes in various variables
4. Vulnerability and climate risk management	Number of months harvest lasts, strategies used by household to cope with food shortages, food availability and trends across year
5. Household characteristics	Gender, wealth rank category, age of household head and spouse, marital status of household head, farming experience in years, educational level of household head, position of household head in community, type of house (roof, walls)

The PRA approach was found relevant because it emphasises recipient influence on problem definition and solution design. The approach has also gained popularity as a means of improving project performance and is viewed as a family of approaches and methods that enable local people to share their knowledge of life and to plan, act and evaluate (Chambers, 1994a and Chambers, 1997). However, there have been suggestions that PRA methods should be used with caution as they may not reveal power dynamics and other power relations that influence the livelihoods of farmers and communities (Goebel, 1998 and Mosse, 1994). Another problem posed by this set of methods is that of regarding society as a homogenous group that has static practices. To guard against these biases, the researcher separated men and women in some of the PRA workshops where it was important to capture differing perceptions. In addition, triangulation with other methods was expected to reduce the cited biases.

Resource mapping

Resource mapping was specifically used to come up with a comprehensive inventory of the resources that the farmers have and explain the vulnerability context of the same farmers based on the assets from which they draw. Apart from identifying the resources in the area, the idea was to assess the location of the same resources and draw conclusions on their accessibility, distribution and availability. A household's "bundle" then determines its vulnerability; the poorest households with the fewest assets are the most vulnerable (Swift, 1989). The importance of this is that it considers not only questions of immediate entitlements, but also how assets determine the ability to buffer against a crisis, both of which will determine a household's vulnerability to hunger. Resource maps are a powerful tool for communities to start recognizing the resources that they already have and that can be used to assist them to reach their livelihood goals (Chambers, 1997).

In addition to understanding what the different resources that exist within the community are, resource mapping was in this study extended to capture data on access to different resources by different socio-economic groups including gender. After drawing the resource maps, in which participants were divided by gender, participants were then asked to brainstorm on issues of access of the resources that they had identified in their mapping exercise. In addition, questions on trends in changes of the resources and reasons for these changes were posed. The idea was to gauge whether these changes had anything to do with climate change or they were due to other factors.

The river code

The river code is a mime or play that is acted by community members with the assistance of a facilitator. It is useful for generating a common livelihood vision for a group or a community, the opportunities that exist within the community to achieve the vision and the constraints to achieve that vision. Role plays or dramas encourage people to enact scenes concerning perceptions, behaviours, issues and problems that need to be discussed in the group (Barton *et al.,* 1997 and Sanginga & Chitsike, 2005). The strength of this play lies in the questions that participants answer as this is when the existing opportunities and constraints can be captured. This technique has similarities with the Participatory Rural Communication Appraisal (PRCA), which pioneered a people-oriented alternative to traditional communication research approaches. In this study, the river code was especially important as the researcher intended to capture farmers' constraints and to understand whether their perceptions of constraints have links with issues of climate change. Moreover, the opportunities that were mentioned by farmers were also important in understanding how they contribute to decreasing the vulnerability of these farmers so as to be able to draw from these opportunities in times of multiple shocks and stresses.

Institutional mapping

Institutional mapping was important to make an inventory of institutions and stakeholders that were operating in the community and that could be involved in helping the communities achieve their visions of desired future conditions (Sanginga & Chitsike, 2005). Institutional mapping was used to understand what institutions exist in the area through a brainstorming session. Brainstorming is a method for generating ideas in a non-judgmental way by inviting participants to freely share their ideas and thoughts about a specific question or issue. It's a first step in a discussion and is usually followed up with other methods (Barton *et al.,* 1997 and Sanginga & Chitsike, 2005). The researcher probed for both formal and informal institutions that are found in their areas and participants had to further state what kind of support each institution provides. At this stage, this list of institutions disregarded climate change related institutions; rather, it took into account all institutions working in the area. Participants then presented in a diagram their relationship with these institutions in the context of food security, climate change issues and local livelihoods. The drawn relationships were then used to establish the extent to which each institution was involved in climate change related activities.

Historical Trend Lines

Historical Trend Analysis entails that participants give historical accounts of how phenomena have changed around them over time using a key set of community indicators for change. These phenomena include customs, practices, values and ecological issues (Freuderberger, 1995). In this context, the technique was used to identify historical trends in farmers' perceptions of impacts of climate variability and change on their livelihoods. Specifically, participants of the exercise were asked to go back to the years as far as they could remember in the last two decades or more. They were asked to recall major occurrences that had a bearing on climate and weather, community resources, and even the political situation. They were then asked to indicate what occurrences had the greatest impact on their livelihoods among the cited events.

Participatory Impact Diagrams

Impact diagrams are a useful way of documenting impact as they focus on both positive and negative impacts and also allow for quantification of such impacts. This is a cause and effect diagram that tries to link certain events with their consequences in a logical manner. Participatory impact diagrams were used to have farmers document noticeable impacts or changes arising from climate occurrences. These diagrams were used as an extension of the historical trend lines that were used to elicit the major climate occurrences in the study sites. Participants were then asked to identify the major climate occurrences that had a bearing on their livelihoods and they then engaged in drawing the impacts that they had noticed in these occurrences.

Daily and current seasonal activity calendars

Seasonal calendars can reveal how different activities are performed and help to identify bottleneck periods and the different activities performed by men and women (Sanginga & Chitsike, 2005). Seasonal calendars in this study were used to capture insights into rainfall patterns, labour demand, crop sequences and identifying periods of particular stress and vulnerability. They were also used to capture insights on gender issues, gender division of labour, decision making and knowledge and on how access to and control of resources varies accordingly. In addition, daily activity and current seasonal activity calendars were used to identify changes that had occurred in seasonal practices and cropping activities in the face of climate change and variability and what had influenced these changes. It was also important to determine how much they still valued indigenous knowledge in terms of the customs that they had maintained and how this had contributed to them building adaptive capacity.

Matrix scoring and ranking

Matrix scoring and ranking was used as a follow up to other methods such as FGDs and brainstorming sessions. This method involves ranking a range of options in the order of their preference, and then discussing their reasons for their ranking. It is useful in obtaining a clear picture of farmers' preferences, their reasons for criteria used to form these preferences and to explore differences amongst farmers in their preferences by gender and other socio-economic categories (Barton *et al.,* 1997; Chambers, 1997 and Sanginga & Chitsike, 2005). In this study, matrix scoring and ranking was used to score and rank crops and livestock that farmers in the study sites grow in order of their preferences based on criteria that they developed themselves. The process of scoring and ranking was done in separate groups of men and women after listing the crops and livestock in plenary and brainstorming sessions. In addition, matrix scoring and ranking was also used to capture priorities in opportunities and constraints. Of particular importance to this study was to gauge if climate variability was a major constraint to farmers' livelihoods, among other constraints.

b) Focus Group Discussions (FGDs)

FGDs are semi structured discussions with a small group of persons sharing a common feature. A shortlist of open ended topics posed as questions is used to focus the discussion (Barton *et al.*, 1997). While FGDs allow for observations by the researcher to gauge diverse views, preferences and priorities in relation to the topic under discussion and further allow for identification of major issues that may need further clarification in other methods, they can also be arenas for contestation and may be biased by power relations in the group (Goebel 1998; Mosse 1994). To address this weakness in the method, the researcher was cautious not to prompt conflicts in discussions and made use of other methods such as the in-depth case studies to probe for any issues that might need a face to face interview with individuals. In this study, FGDs were used to capture preliminary information which was later followed up with other methods. This included information on farmers' opportunities and constraints to their livelihoods. There was need to have thorough understanding of the opportunities that they could take advantage of in times of crises and what constraints they were faced with in their farming systems, and if climate change was one of them. Moreover, FGDs were used to elicit information on the existing farming system in terms of what were the priority crops that farmers were growing and what was their rationale for growing them, what technologies they used and their cropping and crop-livestock systems.

c) In-depth case study analysis

The qualitative and quantitative assessments were supplemented by in-depth case studies. One strength of in-depth case studies is that they provide 'lived reality' (Hodkingson & Hodkingson 2001). These cases were useful in bringing out concrete experiences of households about how they had coped and adapted to climate change. The method involved identifying specific individuals during visits to the site and during PRA exercises. These individuals were then interviewed in depth to come up with stories that expose the coping and adaptive strategies that they had used in the face of shocks such as climate variability and others.

4.3.7 SECONDARY SOURCES OF DATA

Secondary data collected was specifically the actual climate data that was collected from the relevant meteorological departments in both Zimbabwe and Zambia. The data from meteorological stations were compared to information provided by farmers on the traditional and indigenous indicators that they used to predict weather patterns.

4.3.8 DATA ANALYSIS

Data collected for the study through qualitative methods was analysed in a thematic approach. This refers to data gathered through PRA techniques, FGDs and in-depth case studies. The thematic approach entailed coding of this data according to the themes that had already been developed for the study based on the objectives of the study, relevant literature reviewed for the study and those emerging from the data collection process. Data for farmer perceptions was categorised into perceptions of climate variability and change, causes of climate change and multiple stressors faced by farmers. In addition, impacts data were categorised into negative and positive impacts and for each of these categories, four themes emerged. These themes were impacts on crop yield, fresh water resources availability, human and livestock health and the socio-economic status of farmers. Finally, data on coping and adaptation to climate variability and change was categorised into response strategies by farmers, coping vis-a-vis adaptation and factors influencing general adaptation.

Survey data was entered and analysed in the Statistical Package for the Social Sciences (SPSS). Data was cleaned and analysed through descriptive frequencies and the Logistic Regression Model. The logistic regression was used to analyze factors that influence whether a household adapts using a certain technology or not. It was specifically used to analyse data for the third objective on coping and adaptation as highlighted in the analytical framework designed for this study (see section 4.3.2). The logistic regression is a model used for prediction of the probability of occurrence of an event by fitting data to a logistic curve. It makes use of several predictor variables that may be either numerical or categorical (Amemiya, 1985). Therefore, the model measured factors that affect use of various coping and adaptation strategies.

The dependent variable, which is Y, is either an adaptation or coping strategy presented in Table 22 or the conservation farming methods presented in Table 23. The general model is;

$Y=b0 + bX1 + bX2+.......... +bXn$

Y=either 0 or 1 where 0 means no use of strategy and 1 represents use of strategy.

Descriptive frequencies were run to understand risk factors, farmers' perceptions of climate change, capital assets and access to and rating of weather information. Inferential tests were done to determine the level of association between variables, namely, the Chi-square test for categorical data and T-tests for continuous data.

4.3.9 FIELDWORK MANAGEMENT AND PROCEDURES

Fieldwork for this study was conducted in three phases. The first phase included field visits initiated in August 2007 when the researcher was part of the project team that undertook the sampling of wards to be in the broader project in the already selected districts in both countries. This was done in consultation with local leadership and other stakeholders in the project. This also involved familiarisation visits with extension departments and meeting farmers who were to be part of the project. Major fieldwork for this study was done in the second phase. This was done in Zambia first, followed by Zimbabwe. In this phase, questionnaire administration was done first for a period of fourteen days before PRAs and

FGDs were done. The questionnaire administration was preceded by a period of two weeks in which the researcher undertook training of enumerators and familiarised with the process and the people involved, in addition to ensuring that all necessary logistical arrangements were in place for the entire field work. In this second phase, PRAs and FGDs were conducted in a period of three weeks in each country.

Effectively, the second phase of the field work was completed in a period of six months in both countries, between March and October 2008. Analysis of data collected in this second phase was done between October and December in 2008. In the last phase of the field work, the researcher undertook in-depth case studies which were conducted in both countries. These were done in a period of 3 months between January and March 2009.

4.3.10 CHALLENGES FACES DURING FIELDWORK

There were several challenges faced during the fieldwork process. First, the researcher had to engage in a process of controlling expectations during data collection from participants, particularly in Zimbabwe. Farmers indicated that they were expecting to get aid from the researcher and her team, given the economic and other challenges that farmers were facing at the time fieldwork was conducted. In addition, these farmers were accustomed to receiving aid from NGOs that were operating in the area. Because of these expectations, farmers tended to under report their resources, a challenge which enumerators tried to address by verifying by physically checking those resources that they could see, including pieces of land and livestock. Triangulation with other methods also served to address this bias.

Second, some farmers had problems in remembering the specific periods of the climate events that had occurred a long time before fieldwork was done. This challenge was addressed by comparing the periods they gave with in-depth case studies. Third, due to the political context in Zimbabwe at the time the fieldwork was carried out, it was difficult for farmers to discuss openly the operations of certain institutions such as government related institutions and the local leadership which was in relation to their livelihoods. In-depth case studies were, therefore, used to fill gaps that were found in the collected data.

4.3.11 LIMITATIONS OF THE STUDY

One of the limitations of the study was on how to separate climate effects from other phenomena that might differ across space. However, this limitation is not unique to this study as there are similar studies that have highlighted the same as a limitation (e. g. Mendelsohn & Dinah, 2005). As in the cited study, this limitation was eased by employing methods that tried as much as possible to link the impacts to climate change. Such methods include matrix scoring and ranking which indicated how climate change was ranked among other stressors and asking for specific impacts in relation to a specific climate parameter. Another limitation of this study was the gathering of actual climate data from relevant meteorological stations. In addition to the problem of locating the relevant people who were in most cases said to be away, many inconsistencies were unravelled in the data. The researcher had to make use of relevant literature on the same sites in order to validate the collected data.

4.4 THE ANALYTICAL FRAMEWORK

4.4.1 THE SUSTAINABLE LIVELIHOODS APPROACH

The Sustainable Livelihoods Framework forms the basis for understanding important concepts, namely, vulnerability context, capital assets, transforming processes and structures, livelihood strategies and livelihood outcomes. The framework also informs the analysis for this study. Several studies on climate variability and change have applied the livelihoods approach to coping and adaptation in rural Africa (Allison & Ellis, 2001; Burton *et al.,* 2003; Broersma *et al.,* 2005; Goulden, 2008; Sarch & Allison, 2000; Sarch & Birkett, 2000 and Ziervogel & Calder, 2003). In addition, many other studies examined the interlinkages between rural livelihoods and climate without necessarily applying the livelihoods framework, but they do give attention to components of the livelihood framework (Cavendish, 2000; Block & Webb, 2001; Davies, 1996; Eriksen *et al.,* 2005; Little *et al.,* 2001a & 2001b; Mortimore & Adams, 2001; Quinn *et al.,* 2003; Roncoli *et al.,* 2001 and Thomas *et al.,* 2005). The livelihoods approach evolved from the 1980s and succeeded in winning the attention of key policy-makers in donor institutions in the early 1990s and Department for International Development (DFID) in 1997. At this time, the framework succeeded in finding its way because of two broad factors; a broad international climate which favoured people-centred approaches and a specific need to mark out a new phase of development practice in DFID (Solesbury, 2003). Although the framework has been widely applied within the field of development projects, it also has its relevance in adaptation to climate variability and change (Burton *et al.,* 2003; Broersma *et al.,* 2005 and Ziervogel & Calder, 2003).

The strength of this framework lies in that it does not really try to present a model of reality. This framework emphasises assets more than vulnerabilities and this has synergies with a focus on adaptation rather than vulnerability to climate change. It enables the researcher to approach analysis from different perspectives and engage in structured and coherent debates about adaptation issues in climate change and how this contributes to farmers' livelihoods. Furthermore, the framework is relevant to this study in that it encompasses some of the key elements of the study such as risk and vulnerability, coping and adaptation issues covered under livelihood strategies and issues to do with asset entitlements (see Figure 16).

The vulnerability context

The vulnerability context in the livelihoods framework is of particular importance to climate change adaptation. This context frames the external context in which people exist. Vulnerability depends upon the assets that a household has the entitlement to food that it possesses and the extent to which the asset holders can adapt (Carney 1998). People's livelihoods and the wider availability of assets are fundamentally affected by trends, shocks and seasonality over which they have limited or no control (DFID, 1999). These trends and shocks include varied factors that are external to the household and can influence the household's livelihoods. These are shocks and trends such as droughts and floods and resource trends and governance issues, among many others (Allison & Ellis 2001; Ellis 2000). In this regard, the approach becomes relevant to this study in analysing risks and the vulnerability context.

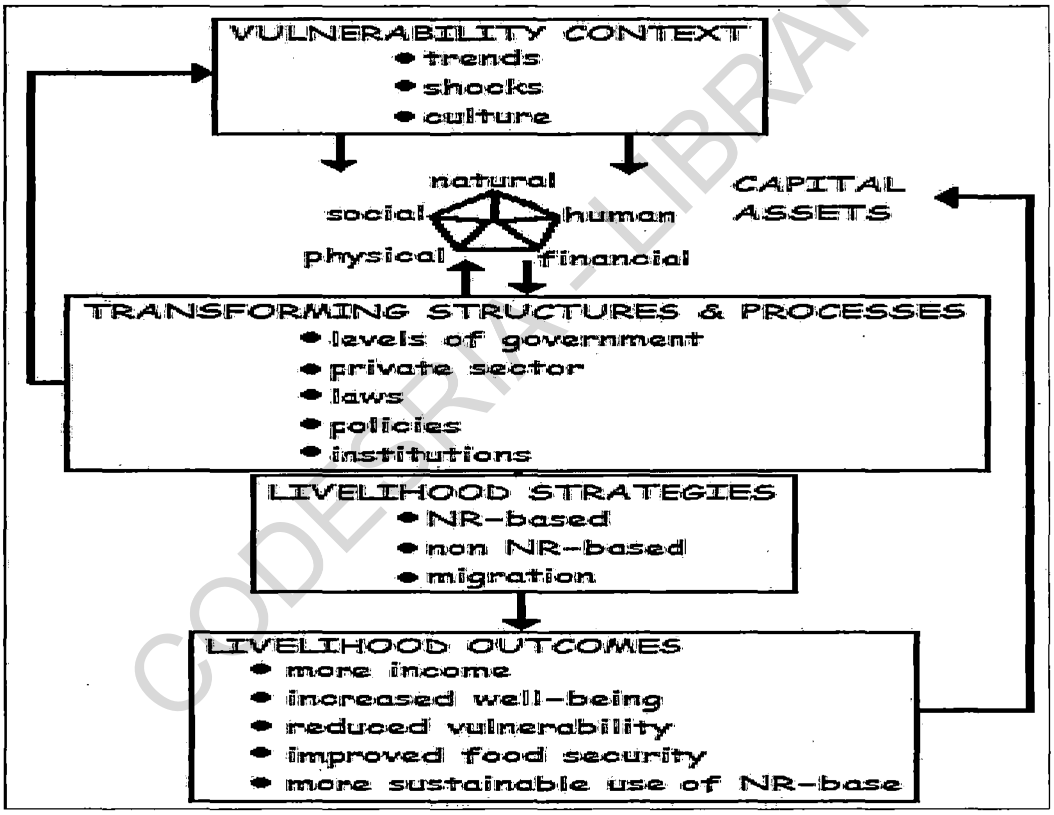


Figure 16: The Sustainable Livelihoods Framework (DFID, 1999)

This brings out the climate and non-climate shocks which farmers in the study sites are faced with. Climate is only one of many sources of stress or risk to livelihoods (Little *et al.,* 2001a; Quinn *et al.,* 2003 and Ziervogel & Calder, 2003). One of the strengths of the framework is that the vulnerability context lists many other shocks and trends. However, it is important to point out at the moment that the same framework falls short of addressing the positive side of the trends that exist. In other words, use of the term 'vulnerability context' draws attention to the fact that these trends are directly or indirectly responsible for hardships faced by people, but it is not always the case that these trends heighten vulnerability. For instance, floods may destroy crops in the lowlands, but upland farmers may take advantage of these floods and engage in cropping activities throughout the year.

Capital assets

The livelihoods framework is founded on a belief that people require a range of assets to achieve positive livelihood outcomes. According to Ellis & Freeman (2005), the aim of the livelihoods approach is to identify the strengths in the livelihoods of the most vulnerable groups in society that can be built upon according to their available assets in order to reduce poverty, rather than focusing on vulnerabilities. The asset base on which farmers draw to engage in various strategies is important and this can be analysed using this framework. A range of assets is needed and no single asset is sufficient on its own to yield the entire livelihood outcomes that people require. The word "capital" has been used widely in literature for these assets, but not strictly in the economic sense, rather, the assets are best thought as livelihood building blocks (DFID 1999). These assets include human (e.g., labour, education), financial (e.g., savings, access to credit), physical (e.g., roads, tools), social (e.g., social networks, reciprocity) and natural assets (e.g., land, water).

Access to these assets occurs in the context of the trends and shocks already highlighted. It is important to understand the dynamic nature of the five capital assets in sustaining people. For instance, while livestock is considered to be physical capital in providing animal traction, it can also generate social capital by providing prestige and connectedness in the community and still be a form of natural capital. Although these capital assets are used separately to analyse the influence of assets on coping and adaptation, each referring to a distinct form of capital asset, this study also considers the importance of these assets as an aggregate in climate change adaptation. Some studies have found asset accumulation to be an advantage because poor households are less able to adapt than households that are better off. For example, social networks are used for sharing information about risks (Little *et al.,* 2001a) and can be drawn upon for assistance at times of food shortage (Roncoli *et al.,* 2001).

Transforming structures and processes

Within the livelihoods framework, transforming structures and processes are institutions, organisations, policies and legislation that shape livelihoods. These processes effectively determine access to various types of capital and have a direct bearing on whether people are able to achieve a feeling of inclusion and well-being (DFID, 1999) and also determine how assets may be utilised. Essentially, the ability to engage in coping and adaptation strategies to achieve outcomes is influenced by institutional and policy processes. All these processes operate within specific contexts such as the people's history, climate change and other trends and shocks. The aspect of transforming structures and processes is relevant to this study as it relates to the understanding of the role of institutions and organisations in provision of a conducive environment for gaining livelihoods and increasing farmers' adaptive capacity to deal with climate change issues in order to mitigate impacts on farmers. More importantly, the framework also allows for analyses of the part played by institutions in restricting access to resources needed for livelihood acquisition. Moreover, institutions may also affect and restrict choices of livelihood strategies through policies that are prohibitive. For instance, farmers may make choices on varieties that they prefer to grow, but these choices depend on choices made by giant, multinational seed companies or traditional authorities and local customs on what is allowed to be planted, and types of inputs that can be applied. Farmers are, therefore, affected by the actions of both local and distant private organisations (DFID, 1999).

Some studies have documented that one of the limitations of the livelihood framework is that it tends to focus on the household, implying that intra-household dynamics such as gender difference may be missed. Furthermore, this focus on the household may also lead to the analysis done glossing over patterns of behaviour at a larger scale than the household if the livelihood approach is the only approach used (Allison & Horemans, 2006). However, this study finds that inclusion of analysis of institutions and policy processes does link the household to external structures and processes such as institutions. Indeed, other studies have applauded the framework for its potential for "linking the micro to the macro" in that it enables the establishment of connections between local realities and the level at which wider institutional and policy context geared towards transforming these realities are formulated (Scoones, 1997).

Livelihood strategies

Access to assets occurs in the context of trends and shocks and results in livelihood strategies made up of a range of different activities. In this thesis, the term" livelihood strategies" is unpacked to refer to coping and adaptive strategies that are employed by farmers in the face of climate change. The dynamics and diversity in household strategies is central to understanding climate change adaptation. Studies have drawn attention to the enormous diversity of livelihood strategies at every level-within geographic areas, across households and over time (DFID, 1999; Scoones *et al.* 1996). This dynamism of livelihood strategies entails that analysis take into account the complexity of coping and adaptation. A common manifestation of this is at the household level where a member of the household lives in different places, temporarily or permanently through migration. At the same time, this member engages in gardening and off farm work when they are in the household. Essentially, it is important to analyse households' and communities' strategies within their wider context (Scoones, 1998).

The livelihood strategies or the household's mixes of activities define the security or viability of the household's livelihood and the sustainability of the environment upon which they depend (Goulden, 2008). In essence, the more choice and flexibility that people have in their livelihood strategies, the greater the ability to withstand or adapt to shocks. Despite the ability of many households to cope with the vagaries of climate change, coping and adaptation is normally unequal with different socio-economic and other groups being able to cope at different levels. Herein lies the importance of understanding adaptation for different people at different levels. Recent studies have demonstrated that different livelihood activities have different requirements, but the general principle is that those who are well endowed with assets are more likely to be able to adapt than those who are not (Deressa *et al.,* 2008; Marenya & Barett, 2007 and Njuki *et al.,* 2008). However, in light of this assertion, there is need for the researcher to be cautious and not cloud other vulnerabilities that the sections of society that are amply asset endowed may face and which may heighten their vulnerability in the face of climate variability and change.

Livelihood outcomes

Livelihood outcomes are achievements or outputs of livelihood strategies. These outcomes include more income, increased well-being, reduced vulnerability, improved food security and more sustainable use of the natural resource base (DFID, 1999). Rather than having the researcher assume that farmers pursue certain outcomes that may appear to be obvious, it is important to understand, from the views of the farmers, what outcomes they pursue and what priorities they have. The key factor of this component in this study is that there is particular focus on farmers' priorities in terms of the environment in which they would like to function, at the same time minimising the impacts of climate change on their livelihoods.

This study keeps in mind that one major difficulty arising from analysis of livelihood outcomes is that they are not necessarily coherent and there may be trade offs and conflict between livelihood outcomes (Scoones, 1998). For instance, in certain locations, engaging in gold panning without licences as a coping strategy is illegal, but it leads to more income as an outcome. In this case income is increased through a practice that is detrimental to the natural resource base. Suffice it to say at this point that though important, livelihood outcomes are not as important to the analysis of this thesis as the other four components that have already been highlighted. The study is more concerned with how farmers draw upon their capital assets to cope and adapt to trends and shocks, particularly climate change in an environment where other players such as institutions and policy processes are in place.

The livelihoods approach has been criticised for its insufficient ability to focus on power and power relations and human agency. Agency strength is related to the set of capacities possessed by particular individuals, that is, "private social capital". Agency attributes to the individual actor the capacity to process social experience and to devise ways of coping with life, even under extreme forms of coercion (Long, 1992:22). Individual or group action is influenced and modified by each other's action as well as by the institutional arrangements forming the context of their action. Likewise, individual or group action affects and influences existing institutional arrangements and actions are not totally determined by or predictable on the basis of contextual factors (Admassie, 1995). It is important to acknowledge that individual and collective actors carry out intentional and purposeful action, but their action is rarely played out as planned nor does it always lead to the intended outcomes.

The framework highlights the importance of social relations and institutions for livelihoods (Bebbington, 1999; Ellis, 1998 & 2000) and fails to recognise that social assets are difficult to observe (Bebbington, 1999). In addition, it fails to acknowledge that social relations and institutions act over a range of scales from the household, to the community and external to the community (Allison & Horemans, 2006 and Tyndall Centre, 2004). The researcher, therefore, employs the framework keeping in mind that there may be gaps that may need to be revisited. Notwithstanding, the framework remains invaluable in identification and analysis of framework components and will be adapted to meet the needs of the given circumstance. The framework can be a useful tool in understanding the impact of sustainable livelihood measures in increasing communities' resilience to climatic stresses - mainly drought - from local people's point of views.

While the livelihoods approach provides a useful framework for examining adaptation at the household and community scales for this study, the limited period of the study limits any attempts to exhaust all the five components of the framework (highlighted in the preceding sub-sections) in analysis, but in stead, focuses on some of the components, which are encompassed in farmers' perceptions of climate variability, impacts from these changes and what strategies farmers have put in place to deal with these changes. This is laid out in an analytical framework constructed by the researcher, which is presented in section 4.4.2.

Analysis of the vulnerability context for farmers in this study is enriched by understanding the specific impact that each climate event has on the social and economic systems that farmers operate in. While the SLA outlines that the vulnerability context is illuminated by analysing trends and shocks that confront farmers, this study has, in addition, used analysis of positive impacts from climate variability to provide more insights on the vulnerability context for the farmers concerned, as outlined in the analytical framework designed for this study. In this regard, the study demonstrates that it is not necessarily all impacts from climate variability and change that may heighten the vulnerability of farmers.

While the SLA provides a framework in which to understand capital assets and policy and institutional processes and their role in cushioning farmers against impacts from climate change, it is beyond the scope of this study to undertake a comprehensive analysis of these assets in the study areas. This is due to limitations of time and resources for a study of this nature. However, reference is made to these components of the SLA in understanding factors that influence adaptation to climate change by farmers through use of a regression model (see section 4.3.8).

Furthermore, while the SLA provides an opportunity to understand livelihood strategies, it only provides a basis for this understanding, but falls short of dissecting the dynamics of these strategies. For this reason, in this thesis, the term "livelihood strategies" is unpacked to refer to coping and adaptive strategies that are employed by farmers in the face of climate change, as highlighted in the framework constructed for this study. The constructed framework, therefore, helps in counteracting limitations of the SLA and enriches analysis and understanding of the distinction in farmers coping and adaptation strategies, beyond just activities to get livelihoods. Moreover, the framework designed for this study further allows for a distinct analysis of factors that influence adaptation, which is not clearly highlighted in the SLA.

4.4.2 EXAMINING THE RELATIONSHIP BETWEEN IMPACTS, FARMERS' PERCEPTIONS AND ADAPTATION PROCESSES

This study uses the analytical framework highlighted in Figure 17, which elaborates on the relationship between farmer perceptions, climate change impacts and adaptation to these impacts to analyse results from the study based on the objectives of this thesis. Reducing risks and creating enabling conditions for rural economic growth and development require a thorough understanding of local perceptions, traditional principles and adaptive strategies pursued by society under different local perspectives (Legesse, 2006). Farmers' perceptions are related to their objectives, their strategies related to their livelihoods, and their actions are guided by perceptions (Eyob, 1999). Smallholder farmers' perceptions of risks are diverse, dynamic and complex. There are differentiated perceptions among various household typologies shown under different socio-economic, cultural and environmental settings. Smallholders' risk perception and risk responses have bearings on the type of intervention measures that would be considered in different parts of the country, across households and agro-ecological zones (Legesse, 2006). However, it is important to note that farmers' ability to perceive changes in climate may not always guarantee adaptation to these changes. Studies done in Africa have found that farmers are aware of the increasing variability in climate, but they are not yet able to respond to it adequately (Mapfumo *et al.,* 2009).

In Southern Africa, agriculture has a low level of production and productivity. A multiple of stressors have been identified as causes of this low production and productivity. In the growing literature on agricultural adaptation to climatic variability and change, it has been increasingly acknowledged that climate represents only one of many sources of risk to which farmers are exposed and respond (Legesse, 2006; Gandure, 2005; Gandure, & Marongwe, 2006 and Reid & Vogel, 2006). Given this situation of multiple stressors, risk management strategies assume a special importance (Belaineh, 2000). Thus, the ways farmers perceive and deal with risk need to be studied in context of impacts from these risks and properly understood. However, it has to be made clear that though these multiple stressors are not entirely the focus of attention; this study does incorporate farmer perceptions of non-climate related stressors and outcomes of climate change.

Furthermore, it would be useful to understand how farmers behave to reduce risk before the actual hazards occur to minimise the consequences depending on their perceptions, accumulated knowledge and experience and how they act after sustaining losses. In relation to this, Webb and von Braun (1994) also argue that coping with risk involves 'a progressive narrowing of options that leads from broad attempts to minimise risk in the long-term through actions designed to limit damage caused by a crisis, to extreme measures aimed at saving individual lives'. There is evidence to show that modern farm managers are now trying to incorporate climatic uncertainty in their decision-making procedures with the objective of minimizing the adverse effects of changing climatic conditions or taking advantage of them on their farm by adopting wise practices and strategies.

It is clear that some farming communities are more aware than others, and therefore, perhaps already better able to adapt to the changing environment (Singh *et al.,* 2007). Furthermore, there is also significant variation between farmers in their awareness and ability to adapt and to recognize the benefits of adapting through integrating appropriate strategies into their farm operations. It is, therefore, important for this study to show understanding factors that influence adaptation. The traditional risk management systems and the various risk reduction mechanisms employed by smallholders need to be studied. This understanding might help to increase sustainable productivity of smallholder agriculture and improve the farmers' coping ability.

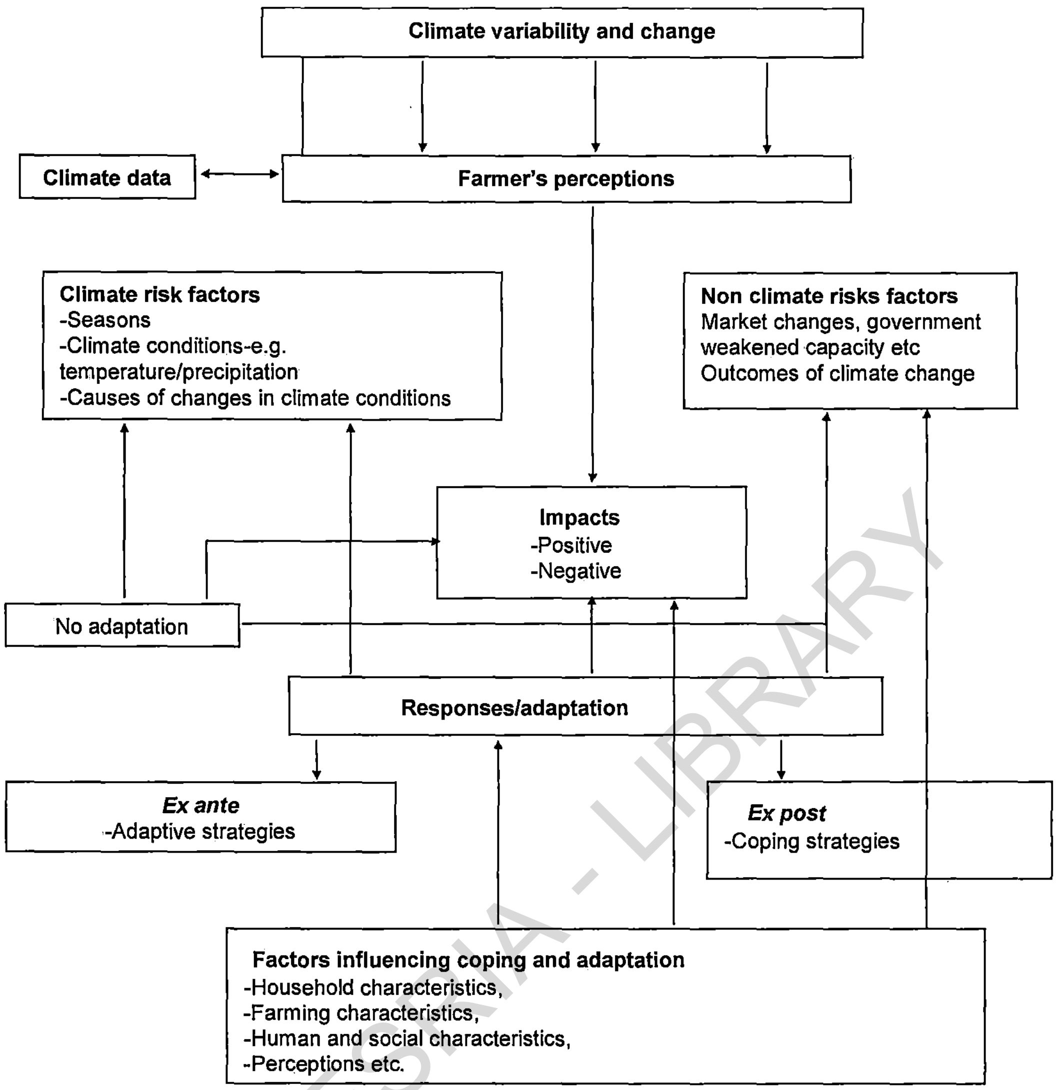


Figure 17: An analytical framework for analysing results in this thesis
Source: Researcher's own construction

4.5 CONCLUSIONS

This chapter has highlighted the location, physical and socio-economic environments of the study areas. It is important to put into context the areas in order to build a background that might later illuminate on some of the results obtained. Moreover, the chapter has also highlighted the importance of both the quantitative and qualitative approaches which form the basis of data collection for this study. Instead of considering these two as rival approaches, this study capitalises on the strengths of each of them and builds on the weaknesses by using other methods that offset certain inherent biases for optimal results. While acknowledging the relevance of the Sustainable Livelihoods Approach to the understanding of climate change adaptation in this study, this chapter has also indicated how analyses of linkages between farmers' perceptions of climate change and their impacts and adaptation to climate change can be done by constructing an analytical framework specifically for this study. Chapter Five presents and analyses the results of the study.

CHAPTER 5: FINDINGS AND DISCUSSION

5.1 INTRODUCTION

This chapter presents the results of the study. The chapter is divided into three parts. Part one presents a description of household characteristics for the sampled households. Part two, which presents farmers' perceptions, is divided into four sections; section one focuses on perceptions of climate variability and change, section two on perceptions regarding other shocks and stressors farmers are subjected to, section three on farmers perceptions regarding impacts of climate variability and change and section four on perceptions of causes of changes in climate. The last part, part three, then presents the strategies that farmers engage in so as to deal with the foregoing shocks. This part is divided into three sections; section one presents response strategies based on climate variability perceptions, section two focuses on coping as distinct from adaptation and section three highlights factors influencing adaptation to climate change in Zimbabwe and Zambia.

5.2 CHARACTERISATIONS OF FARMERS AND THEIR FARMING SYSTEMS

5.2.1 HOUSEHOLD CHARACTERISTICS

The average age of sampled household heads is higher for Zimbabwe than for Zambia districts. In the sample for the study, there are more female headed households in Lupane and Lower Gweru than there are in Sinazongwe and Monzen (Figure 18). Both these factors could be attributed to the fact that migration of the youth has been on the increase in the study districts in Zimbabwe as highlighted in Chapter Four. Female headship is typically expected to increase the likelihood of the household being poor, a factor which may have implications on how a household responds to climate variability. The marital status of a household may also be linked to the way in which they respond to climate variability based on the resources at their disposal.

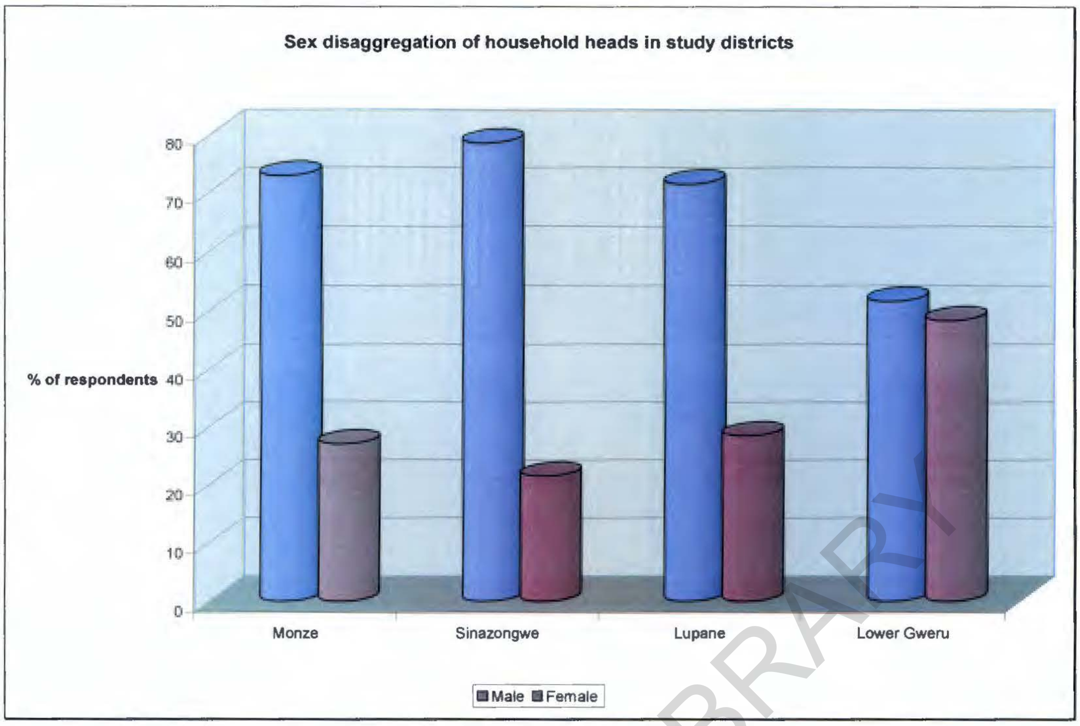


Figure 18: Disaggregation of households by sex in study districts

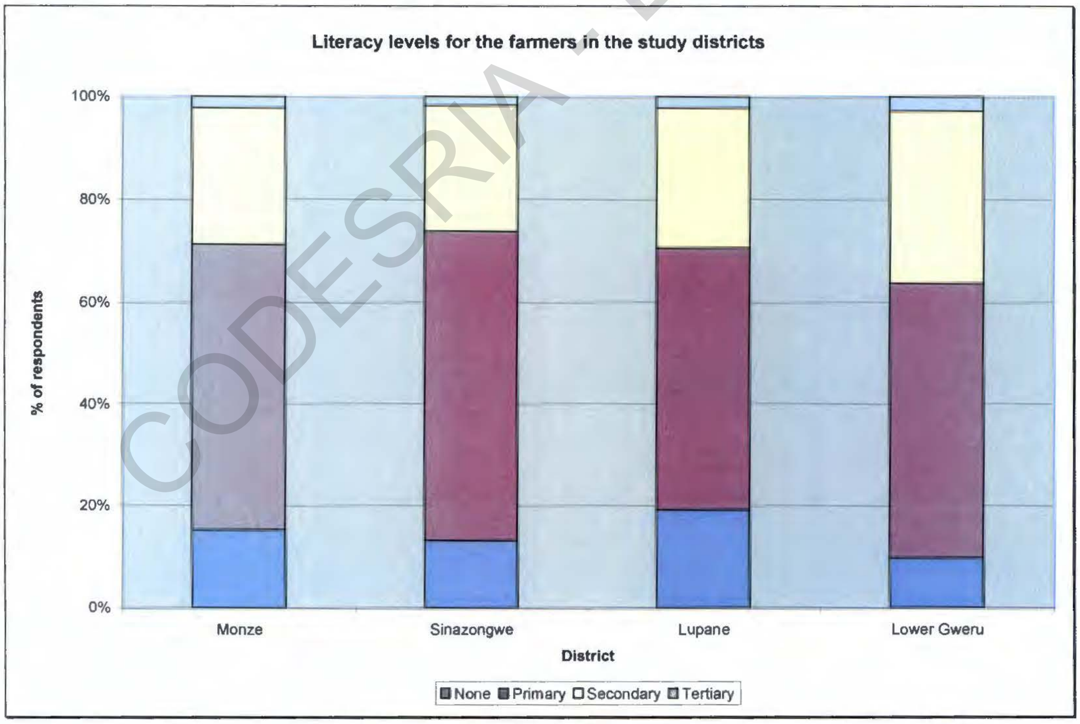


Figure 19: Education levels in the study districts

Survey results further show that the highest level of education that the respondents have acquired is primary level and this does not differ significantly across the two countries (Figure that most farmers are functionally literate. However, there are more farmers who have reached the secondary level in Lupane and Lower Gweru than in Monze and Sinazongwe. The education level of the household head is considered to be important since heads of household are the decision makers of the household. In general, a more educated person is considered to be in a better position to make informed decisions. The assumption herein is that an educated person is more able to process information and use it to inform decisions, in addition to enabling the individual to perform tasks more efficiently than a less educated individual. Literature highlights that education may enhance farm productivity directly by improving the quality of labour. In addition, education is important to farm production, especially in a rapidly changing technological or economic environment (Sharada, 1999 and Shultz, 1964 & 1975).

5.2.2 TRENDS IN CROPS GROWN IN STUDY DISTRICTS

Crops mostly grown in Lupane include maize, millet and sorghum. The growing of millet and sorghum in this district is consistent with its climate as highlighted in Chapter Four. Though to a much lesser extent, cowpea is another crop that is grown in Lupane. In the past five years, although farmers have started growing millet slightly less than they did before, the trend had been more or less the same for the other crops (see Figure 20). For Lower Gweru, maize, groundnuts, Bambara nuts and sorghum have been grown the most. There has been an upward trend for all the cited crops except sorghum. This implies that while farmers in this district, which is wetter than Lupane, grow crops which are well suited for the climate of the area, these farmers are increasingly realising the importance of growing drought tolerant crops such as sorghum. The growing of sorghum in Lower Gweru is justified by farmers' perceptions in this district, which point towards more unpredictability of the rains and a higher incidence of dry spells (see section 5.2.1).

In Monze, maize, ground nuts, cowpeas and sweet potatoes are commonly grown. All these crops are well suited for the wet conditions that generally characterise this district. There have not been major changes in the trends over a period of five years. For Sinazongwe, maize, cotton sorghum and millet have been commonly grown although there have been pockets of farmers also growing cowpeas and ground nuts. This is consistent with the low and erratic rains that characterise Sinazongwe district. The trends as illustrated in Figure 21 have generally been the same over a period of five years although slightly less maize and more cotton is currently being grown.

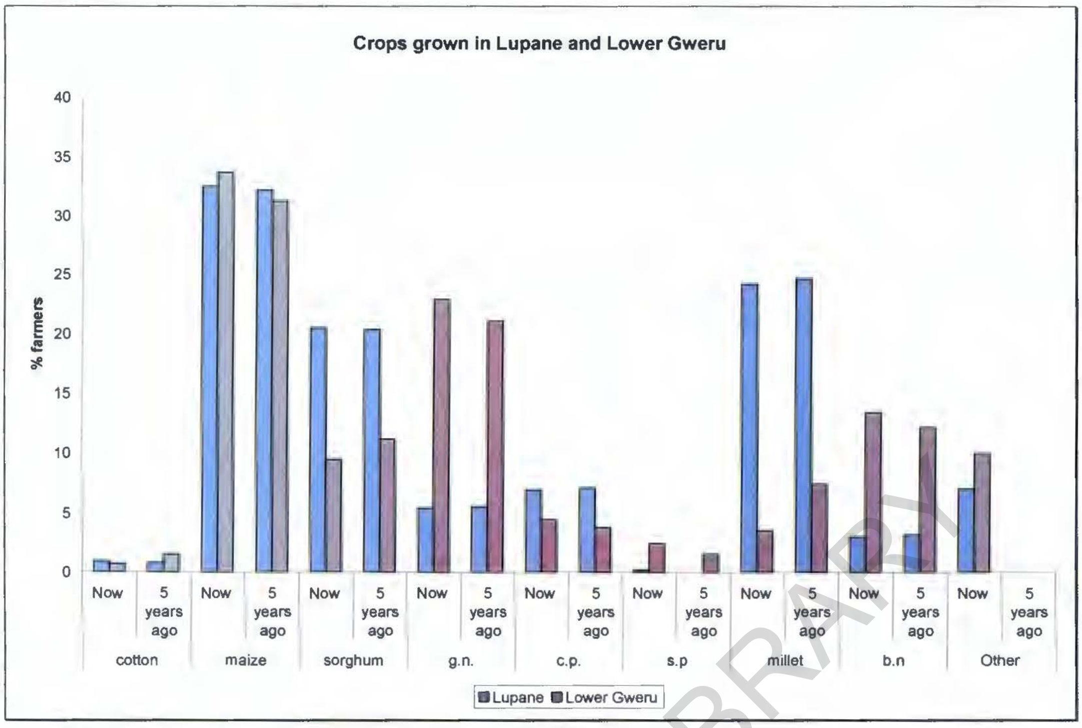


Figure 20: Crops grown in the study districts in Zimbabwe

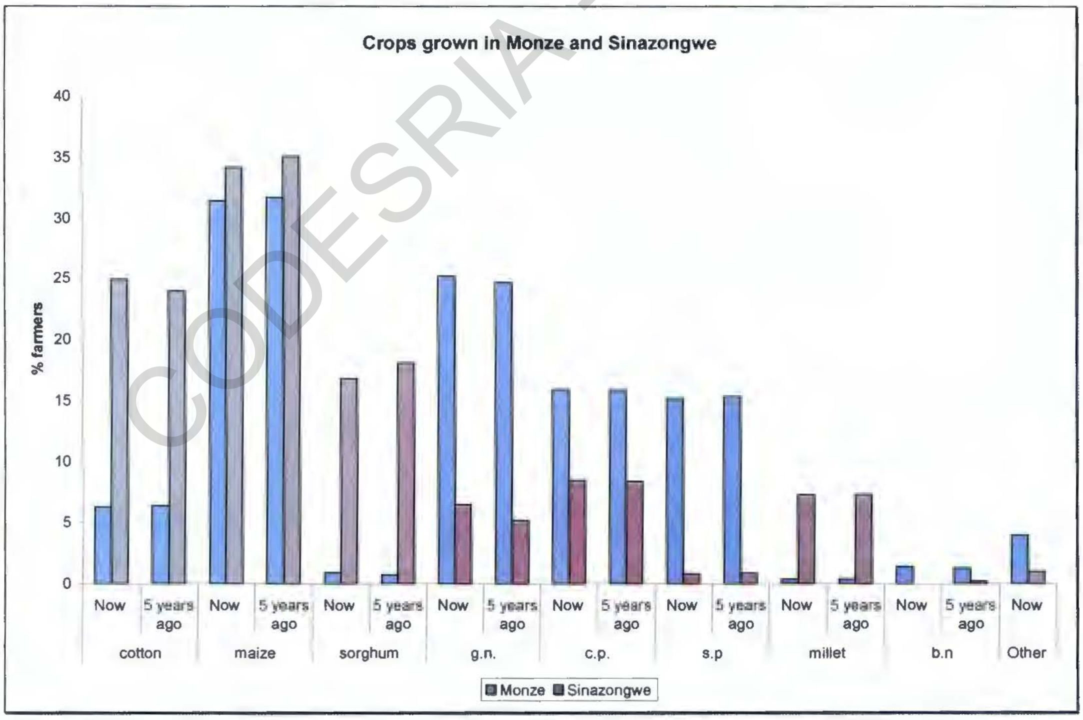


Figure 21: Crops grown in the study districts in Zambia

5.2.3 ASSET OWNERSHIP

One of the bases of growth and poverty reduction is access to assets (Brooks *et al.,* 2005). Farming implements, household assets such as radios and televisions and livestock are important for increasing household agricultural productivity. Farmers in Lupane and Lower Gweru have more agricultural implements than those in Monze and Sinazongwe. This is true for most of the implements except for the ridging plough, sprayer and cultivator, which are owned by more farmers in Zambia districts (see Table 11). In the case of irrigation equipment, this is largely owned by Monze and Lower Gweru farmers than Sinazongwe and Lupane farmers. This is not unexpected considering that these districts are wetter than Sinazongwe and Lupane districts and are therefore more likely to engage in irrigation activities.

Similarly, except for the mobile phone and bicycle, there are more farmers in Zimbabwe districts who own household assets than in Zambia districts. With regards to livestock, Lupane and Sinazongwe farmers own more cattle than Monze and Lower Gweru farmers. In the case of all the other livestock, there are more farmers in Lupane than there are in Lower Gweru who own livestock. It has already been highlighted that the Southern Province in Zambia, where the study districts are located, is acknowledged to hold the largest population of livestock in the country. In addition, Lupane and Sinazongwe's economies are largely livestock based. A study done by FAO (2008) shows that in Matabeleland livestock is an important source of income compared to other areas which have mixed production. Gweru district is such an area with mixed production of fodder crops, horticulture and livestock production.

There is average to above average percentage ownership of critical assets such as livestock, ox drawn carts and ploughs. However, the major concern is that apparently, there is limited technological advancement in terms of agricultural mechanisation through ownership of assets such as irrigation equipment and planters, among other such critical implements. In the same respect, the negligible ownership of mobile phones may be counter productive for farmers, particularly in Lupane and Lower Gweru. Mobile phones have been used as a means of communication of climate related information by independent media in and outside Zimbabwe. Another emerging trend in all the districts is that farmers are aware of the importance of growing crops that are suitable for existing climatic conditions.

Table 11: Ownership of assets by households in study districts in Zimbabwe and Zambia

	Monze (N=180) %	Sinazongwe (N=180) %	Lupane (N=180) %	Lower Gweru (N=180) %	Chi value
Agricultural implements					
Ox-drawn plough	44	52	68	64	26.315***
Ox-cart	23	13	46	40	56.811***
Harrow	17	5	10	32	50.531***
Ridging plough	13	6	1	3	27.213***
Cultivator	35	6	12	25	48.845***
Irrigation equipment	8	4	1	11	18.114***
Sprayer	28	53	10	9	113.847***
Hoe	94	97	99	97	5.164
Ripper	1	5	1	1	13.609***
Axe	34	46	98	94	229.778***
Planter	7	1	1	3	10.791***
Household assets					
Radio/tv	65	57	65	68	47.912***
Bicycle	56	48	26	28	51.664***
Mobile phone	16	23	5	5	41.259***
Sewing machine	4	6	10	13	9.214**
Watch/clock	38	22	40	46	22.074***
Paraffin stove	5	1	2	6	9.264**
Livestock					
Cattle	43	54	63	39	24.453***
Goats	77	69	63	37	65.188***
Poultry	91	81	93	81	18.001***
Donkeys	3	1	41	20	99.412***
Pigs	22	14	3	0	51.617***

, * significant at the 5%, 1% levels

5.3 FARMER PERCEPTIONS OF CLIMATE VARIABILITY AND CHANGE, CAUSES OF THESE CHANGES AND MULTIPLE STRESSORS

To understand farmers' perceptions of climate and non-climate risks, historical trend analysis, resource mapping, matrix scoring and ranking and participatory impact diagrams were used in addition to the household survey (see Chapter Four, Section 4.2). The results of these exercises are presented in this section. This study recognises the importance of understanding farmers' perceptions in the context of climate related changes and the contribution of these perceptions to climate change adaptation. While there is literature to demonstrate that at the centre of the adaptive process there is the individual farmer who is free to make a specific choice such as what to plant, how much land to cultivate and the resources to be employed (Crosson, 1986 & 1993), there is an alternative approach which underscores how individuals perceive their environment and make decisions, with maladaptations attributed to problems in perception, cognition or the lack of available information (see, for example, Diggs, 1991; Saarinen, 1966 and Taylor *et al.,* 1988). The main point is that from whatever level these adaptation measures are taken, the adaptation and coping measures depend on households' perception of extreme events and the problems associated with them (Davies, 1993). This literature points towards the central role that farmer perceptions play in adaptation, making it essential for this study to understand farmer perceptions of climate change and their impacts. Farmer perceptions are considered to be critical as a determinant of and necessary precondition for adaptation (Deressa *et al.,* 2008; Grothmann & Patt, 2005; Koch *et al.*, 2006; Maddison, 2006; Patt & Gwata, 2002; Smit *et al.*, 2001 and Vedwan & Rhoades, 2001).

5.3.1 PERCEPTIONS OF CLIMATE VARIABILITY AND CHANGE

5.3.1.1 Perceptions of changes in weather patterns

Data from the survey indicate that above 70% of the farmers in all the four districts have been aware of significant changes in weather patterns over the past five years (see Figure 22). This consciousness of the changes in weather conditions is corroborated by existing evidence of climate data analysis presented in Table 12. It is interesting to note that there are more farmers in Monze and Lower Gweru indicating that they have been aware of these changes than there are in Sinazongwe and Lupane. The implication in this finding is that farmers, who are accustomed to dry conditions, are less conscious of changes in climate than farmers in wetter areas who may experience a significant reduction in crop yield and due to these changes. Therefore, it appears that farmers closely associate changes in weather conditions with crop productivity. Farmers in Sinazongwe and Lupane have already been highlighted as having low crop productivity in most seasons (see Chapter Four). In addition, reductions in rainfall amount in dry areas could be less noticeable than in wetter areas.

However, significant proportions of farmers in both countries indicated that they have observed changes in climate for all the parametres highlighted (see Figure 24). The highest percentage of farmers who have experienced increased floods/excessive rains is from Monze (85%) and Sinazongwe (72%), with much lower percentages for this climate parameter for farmers in both districts in Zimbabwe. This is the case because Lupane and Lower Gweru farmers indicated that what they have witnessed are rather excessive rains and not floods per se. Above 58% of farmers in all districts have experienced droughts and a greater proportion of farmers in Monze and Sinazongwe reported to have observed dry spells than in Lupane and Lower Gweru. The percentage of farmers who have observed early rains is much lower in all the districts than for the other climate parameters. What is emerging from these findings is that climate variability is on the increase in both countries.

Table 12: Meteorological data analysis results

Changes	Zimbabwe	Zambia
Increased seasons without enough rainfall	Five percent significant positive trend for DJF and MAM for the pxcdd. However, JJA show a non significant decrease in the longest dry period. SON and ANN. indicate positive increase in the longest dry period.	Negative trends (5% level of significance) for DJF longest dry periods. The rest of the seasons show positive trends MAM and ANN. (5% significance) as well as for JJA and SON (non significant).
Increased floods	The longest wet periods (pxcwd) though not significant, show increases for MAM and JJA; and decreases for DJF, SON and ANN. The heavy rainfall days (pnl90) have decreased for DJF and increased for MAM (though not significant for both seasons).	The longest wet periods (pxcwd) have de creased over the years except for SON. DJF and ANN. show significance at 5%. For Moorings, the heavy rainfall days (pnl90) have decreased for MAM and increased for DJF (though not significant for both seasons).
Extremes in Temperatures	The heat-wave durations (txhw90) have significantly been increasing over the years for MAM, JJA, ANN. (all at 10% LOS), SON (at 5% LOS) and DJF (not significant).	The heat-wave durations (txhw90) have increased over the years for MAM (at 10% LOS), JJA (5% LOS), SON (not significant), ANN. (not significant), and decreased for DJF (not significant).
Long Dry Spells	The DJF and MAM seasons show that the longest dry periods (pxcdd) have increased with time at 5% level of significance. Overally, ANN. also show positive increase though not significant.	Longest dry periods have decreased (5% significance) for the DJF and for MAM the periods show increases (at 5% LOS). Overally, ANN. also shows positive increase at 5% significance level.

*DJF (December, January, February), MAM (March, April, May), JJA (June, July, August), SON (September, October, November)

*ANN. (Annual value of either rainfall or temperature, depending on context)

***Meteorological data analysis by Murewi (2009)**

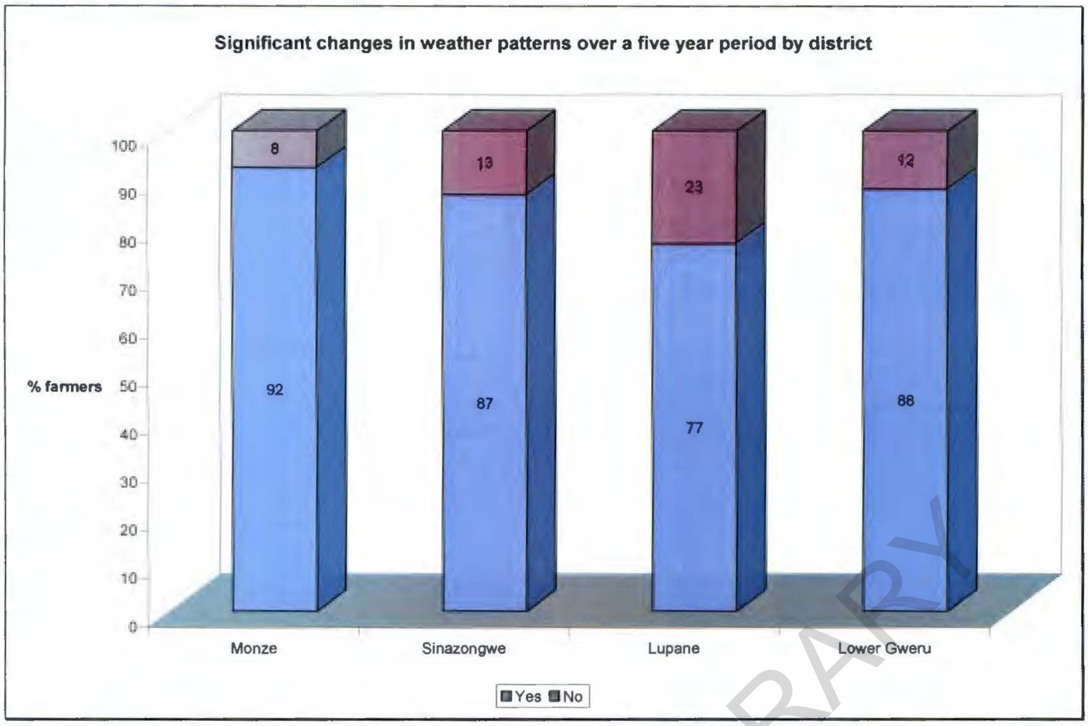


Figure 22: Proportions of farmers who have been aware of weather changes over five years

For precipitation, as reported in historical trend lines, farmers in Monze indicated that the drought occurrences that they could recall which had a major impact on their livelihoods were those of the 1992/93 and the 1995/96 seasons. While they highlighted that they have experienced major floods in the 2007/08 season, they also indicated that there were other years when they received excessive rains which they could not quite classify under floods but which were destructive in the 2002/03 season. This says more about variations than deviations from some long-term trend, implying that farmers have witnessed climate variability rather than climate change (see consistence with Nanja (2004) analysis-Figure 23). One woman in Mweenechepa village in Monze had this to say about the floods in the 2007/8 season; *'Even when you walked, you could feel the earth moving with you up and down as the ground was constantly too wet.'* While farmers in Sinazongwe highlighted the same periods as drought periods, they also added that 2001/02 was a drought year for them. They experienced floods in the same year that was indicated by Monze farmers (2007/08). This is congruent with the observation that was made based on climate data for the Southern Province that all along, the major problem in the South is that there is often not enough rain and so the risks have been concerned mainly with drought. Floods are a recent phenomenon in Southern Africa (Stern, 2004).

Annual rainfall trend for Moorings[14]

[14] Mooring rainfall observing station is a representative station for the project area with long-term rainfall records.

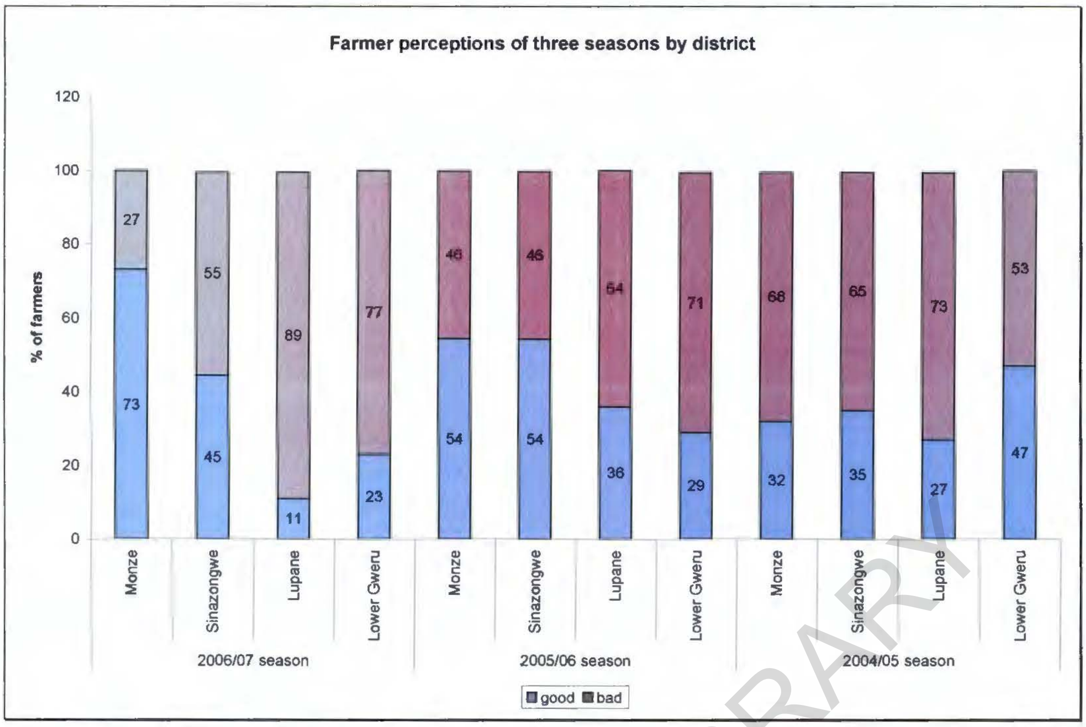


Figure 26: Perceptions of changes in weather for specific seasons between 2004 and 2007

5.3.1.2 Perceptions of causes of changes and variability in climate

The greater proportion of farmers in both countries perceives climate change as purely a natural phenomenon, without any human intervention being responsible for climate change. This perception is more dominant in Sinazongwe and Monze than in Lupane and Lower Gweru (see Figures 24 to 27). These natural causes include natural changes in winters, low/high temperatures and changes in wind movement, among others. In addition, there is an indication that farmers in both countries seriously disregard the role that is played by anthropogenic activities in the increase of climate variability and change. This fact is further reinforced by significantly high percentages of farmers in Lupane (45%) and Lower Gweru (27%), who assert that causes of climate change have also been due to factors such as the wrath of cultural spirits and God who have meted out punishment to Zimbabwe. The punishment has been for the failure of people to continue to appease their spirits and conduct traditional rites such as the rain making ceremony *(mukwerera)* for asking for rain from God and for showing gratitude for the rains in the previous season.

Human induced causes of climate change, such as deforestation were highlighted, particularly by farmers in Monze (33%) and Sinazongwe (17%). In essence, Monze and Sinazongwe farmers who indicated that they are aware of causes of climate change dwell

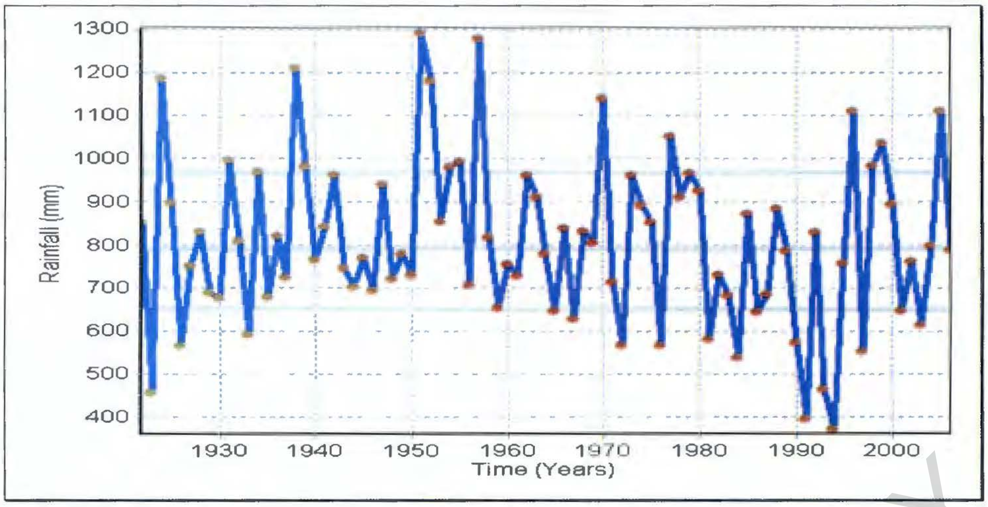


Figure 23: Rainfall analysis for Southern Zambia by Nanja (2004)

Farmers in Lower Gweru and Lupane concurred that they experienced droughts in the 1992/93, 1994/95, and 2001/03 seasons. They also highlighted that though they have not experienced floods, they have experienced excessive rains which have impacted negatively on them in many ways. These farmers remembered the 1978/79, 1999/2000 and 2007/08 as the seasons in which they received excessive rains. This matches with available rainfall data, which shows that the 1999/2000 season was a La Nina season (Stern, 2004). However, the percentage of farmers who witnessed excessive rains is significantly higher in Lower Gweru (43%) than Lupane (28%) (see Figure 24).

Farmers in Zimbabwe districts generally concur that in the 1980s it was easy to predict the coming season and the seasons were distinct but now the rains have become more and more unpredictable beginning around 1995. Moreover, they also highlighted that now they were experiencing shorter rain seasons than before. Rains would start from October and stretch up to April but now rains are coming late around November and in most cases ending around February. The farmers who were interviewed indicated that in the past, rain seasons started around 15 October but now it only starts raining around the first or second week of November. When the rains come early, like in the 2007/08 season, they normally fall heavily and cause damage to people and crops.

The same sentiments were given by farmers in Monze and Sinazongwe, that the rains have become more and more unpredictable than before. These farmers also said that they used to expect the first rains in October but now they have to wait for mid-November and sometimes December for the first rains to come. Farmers indicated that now there is a higher incidence of dry spells around December and January, which is the period when they expected most of the rains for the season. However, in Monze and Sinazongwe, farmers cited the unpredictability of the rains as having started in the late 1980s. These farmers also indicated that they have started experiencing heavy rains and floods for the past two seasons. This is congruent with the finding that only small percentages of farmers attested to witnessing early rains (see Figure 24).

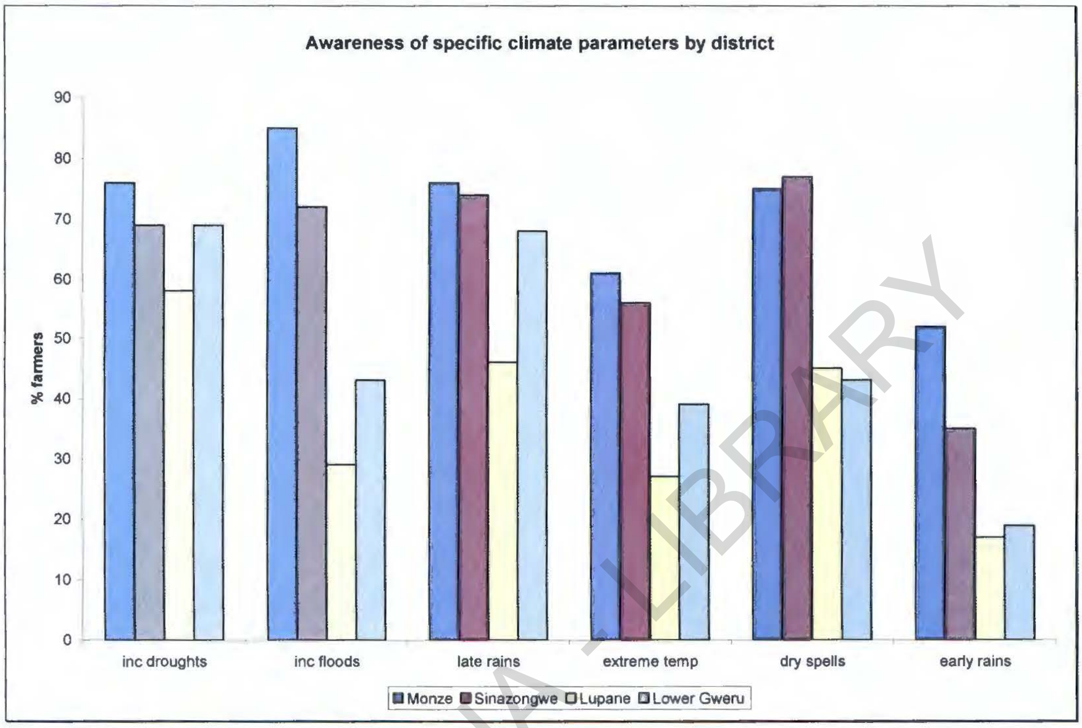


Figure 24: Farmers' awareness of climate parameters in the sampled districts

The foregoing picture of increasing climate variability in the four sampled districts is consistent with the sombre picture detailed in literature on climate variability and change in Africa. In southern Africa, among the countries worst affected by droughts are Zambia and Zimbabwe, as highlighted in Chapter Two. In addition, there appears to be an increasing trend towards a late start to the rain season, prolonged mid-season droughts, and shorter growing seasons in Southern Africa (Cooper *et al.*, 2007; Love *et al.*, 2006; Twomlow *et al.*, 2008 and Waiswa, 2003). Moreover, variability in the annual rainfall total in the Southern Province in Zambia is more pronounced from the 1990s to date, where rainfall totals have frequently been seen below the 20 percentile and 80 percentile. The two lowest rainfall totals were also experienced from 1991 (Nanja, 2004).

With regards to temperature, farmers in Lupane and Lower Gweru highlighted that temperatures have become hotter than before. Specifically, they were of the opinion that for the past five years, while the duration of the summer season has remained consistent, that is between September and April/May, the highest temperatures have been witnessed for an extended period from October to December and sometimes January. This is unlike the situation before this period when they would experience the highest temperatures in September and October. In addition, farmers had also started experiencing warmer winters than before. These winters have also in recent years been extended to mid-September, a factor which they associated with the unpredictability and the late onset of the rains. Similarly, in a study done across ten African countries, which include Zimbabwe and Zambia, farmers generally considered temperatures to have risen and precipitation to have decreased (Maddison, 2006). Farmers in Monze and Sinazongwe also reported that temperatures have become warmer than before.

What is of interest is that there are more farmers in Monze and Sinazongwe than there are in Lupane and Lower Gweru indicating that they have witnessed changes in all the climate parametres highlighted in Figure 24. This could be linked to the fact that there are significantly more farmers in Zambia districts than there are in Zimbabwe districts who have access to weather information (see Figure 25). This is based on the assumption that while farmers may already have a certain way of perceiving climate variability, access to weather forecasts enhances awareness of climate changes. Previous research has highlighted the critical role that access to weather information plays in shaping farmers' perceptions of climate variability and change (Deressa *et al.,* 2009 and Mano & Nhemachena, 2007).

Those farmers with access to weather information could possibly be more inclined to notice changes in climate than those who have less access. For instance, at the time field work was conducted, farmers in Monze had weekly access to Radio Chikuni, which presents weather forecasts. Maddison (2006) shows that farmers with access to weather information and with more years of farming experience are more likely to be aware of changes in climate. Although farmers in Lupane and Lower Gweru on average have more years of farming experience than those in Monze and Sinazongwe (see Table 11), the experience is most likely rendered ineffective due to limited access to weather information, which would otherwise conscientise farmers accordingly. This finding is consistent with previous research, which has found that information on a potential threat may alter an individual's behaviour (Lowe & Lorenzoni 2006).

It also appears that farmers who have a lot of challenges to contend with may have their attention divided so much that they would less likely be able to notice changes in climate. In the same context, these multiple challenges may present a farmer with an option to prioritise concerns and cloud their perceptions of climate variability and change. This finding is buttressed by the fact that perceptions of danger and risk have been considered to be shaped by psychological, social, cultural and institutional processes (Lowe & Lorenzoni, 2006). It also appears that perceptions of farmers in Lupane and Lower Gweru were clouded by a higher incidence of multiple stressors that the country was facing at the time (a detailed presentation of these stressors is presented in section 5.2.2). These farmers stressed that three consecutive seasons since 2004 were all bad seasons for them, while Monze and Sinazongwe farmers indicated that there were both good and bad seasons in the same period (see Figure 26). A series of interlocking problems including hyper-inflation, perennial and acute food shortages, shortages of other basic commodities in the formal market and a critical shortage of farming inputs resulted in the ballooning of the proportion of the national population trapped in cycles of poverty and vulnerability in Zimbabwe (Gandure & Marongwe, 2006).

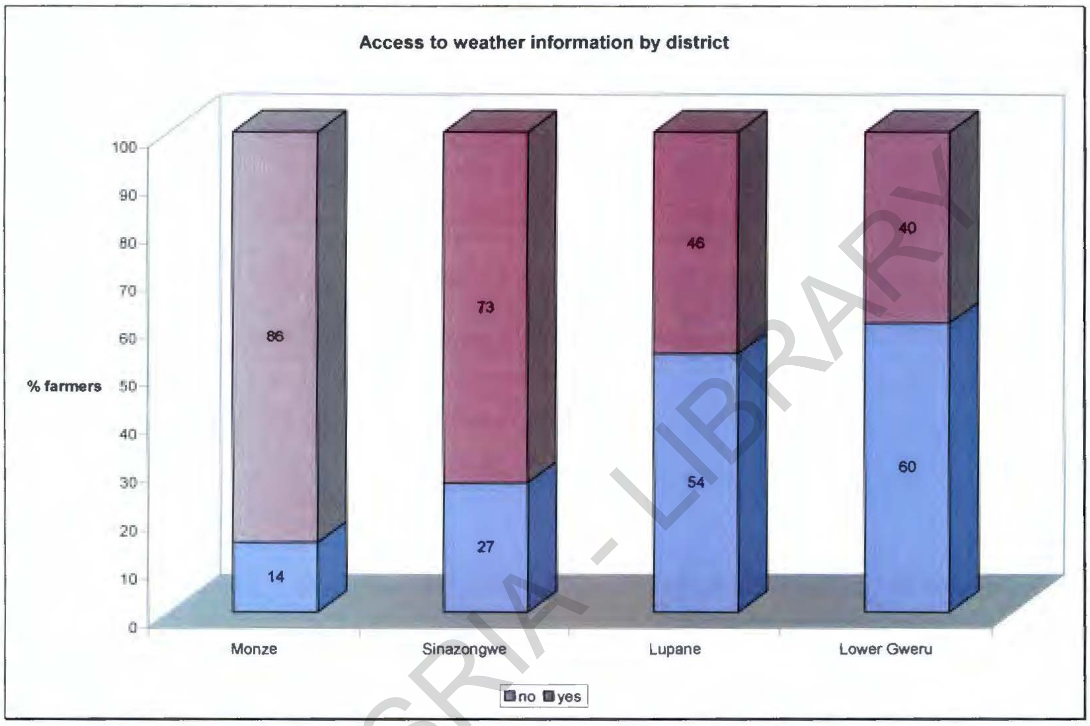


Figure 25: Farmers' access to weather information in the study districts in Zimbabwe and Zambia

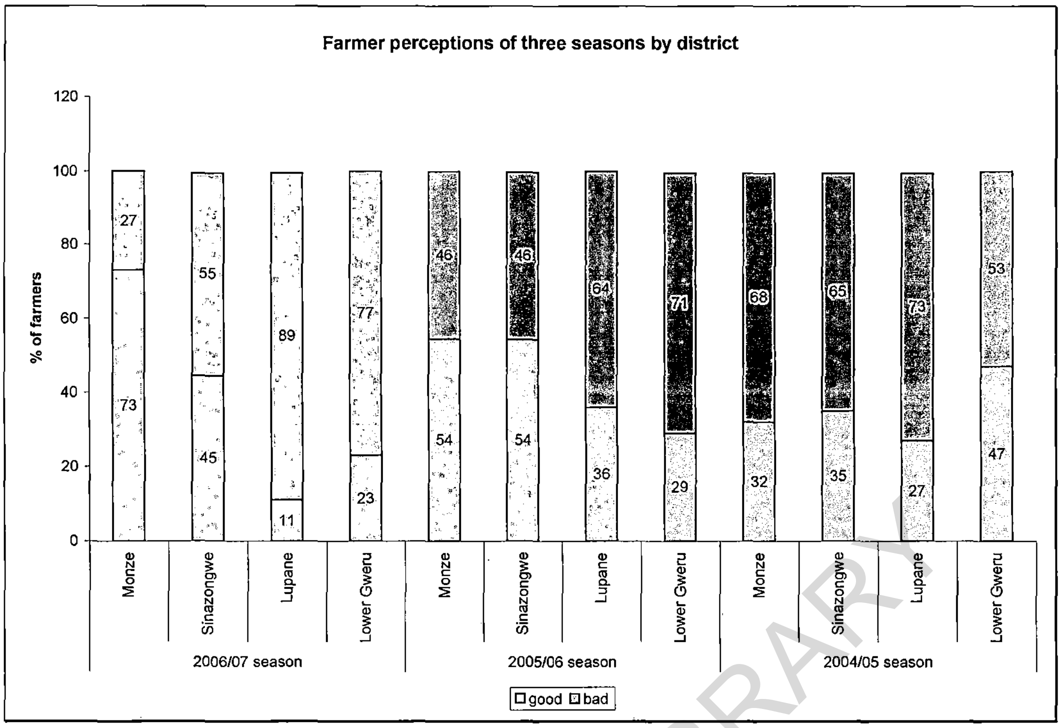


Figure 26: Perceptions of changes in weather for specific seasons between 2004 and 2007

5.3.1.2 Perceptions of causes of changes and variability in climate

The greater proportion of farmers in both countries perceives climate change as purely a natural phenomenon, without any human intervention being responsible for climate change. This perception is more dominant in Sinazongwe and Monze than in Lupane and Lower Gweru (see Figures 24 to 27). These natural causes include natural changes in winters, low/high temperatures and changes in wind movement, among others. In addition, there is an indication that farmers in both countries seriously disregard the role that is played by anthropogenic activities in the increase of climate variability and change. This fact is further reinforced by significantly high percentages of farmers in Lupane (45%) and Lower Gweru (27%), who assert that causes of climate change have also been due to factors such as the wrath of cultural spirits and God who have meted out punishment to Zimbabwe. The punishment has been for the failure of people to continue to appease their spirits and conduct traditional rites such as the rain making ceremony *(mukwerera)* for asking for rain from God and for showing gratitude for the rains in the previous season.

Human induced causes of climate change, such as deforestation were highlighted, particularly by farmers in Monze (33%) and Sinazongwe (17%). In essence, Monze and Sinazongwe farmers who indicated that they are aware of causes of climate change dwell more on the scientific and technical issues such as natural causes than Lupane and Lower Gweru farmers who dwell more on cultural and spiritual issues. Understanding of farmers' perceptions of causes of climate change is important as this understanding might be decisive in determining farmers' responses and mitigation measures to the crisis. In essence, if farmers are not aware of the extent to which anthropogenic activities alter climate related processes, the implication for adaptation and mitigation is negative. In the same respect, the fact that significant percentages of farmers in all districts indicated that they are not aware of the causes of climate change (see Figures 27 to 30) may imply that these farmers would not make efforts to address human activities that may lead to climate change and variability. This finding is consistent with lessons drawn from case studies presented in Chapter Three, which also highlight farmers from Burkina Faso indicating that they are not aware of the causes of changes in climate.

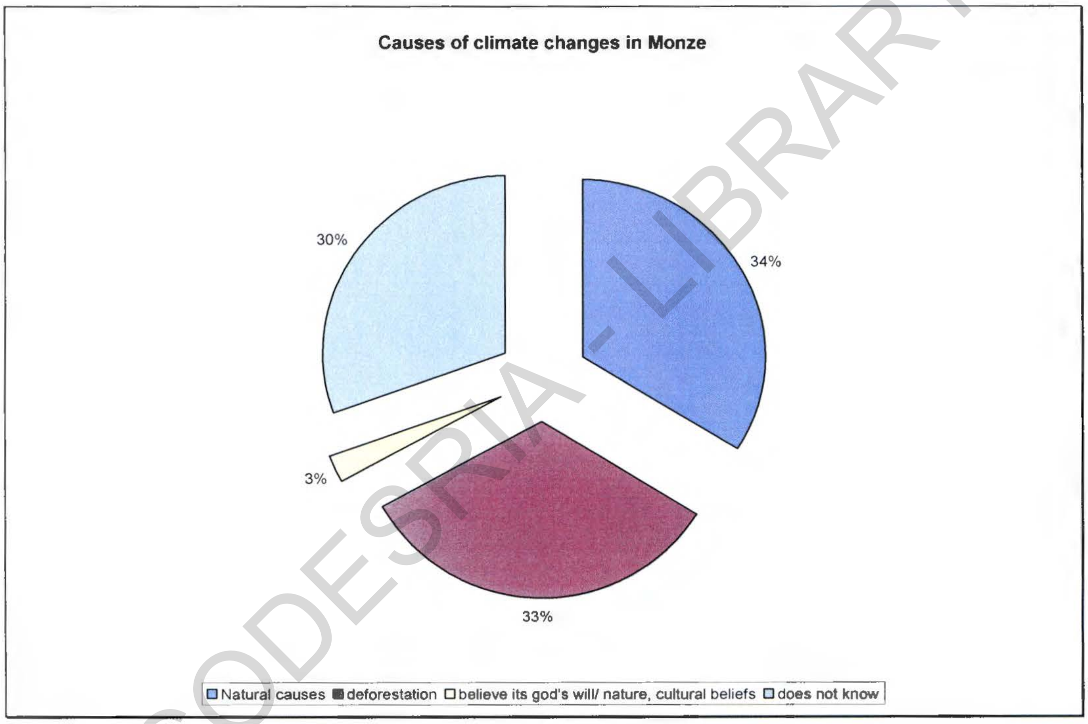


Figure 27: Perceptions regarding causes of climate change in Monze

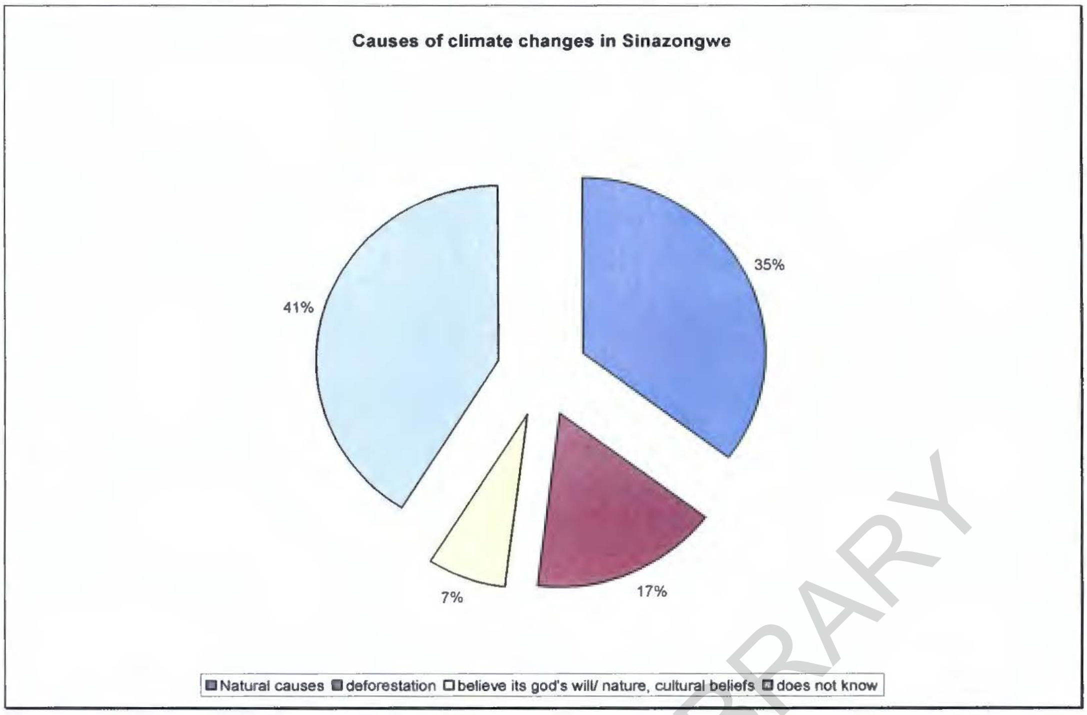


Figure 28: Perceptions regarding causes of climate change in Sinazongwe

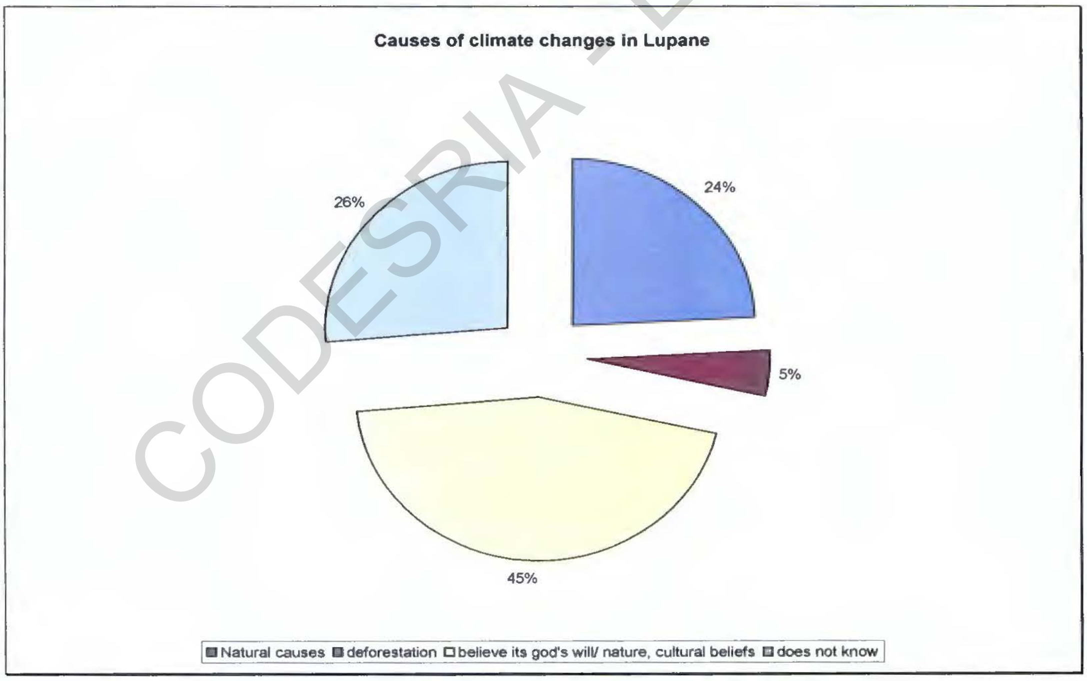


Figure 29: Perceptions regarding causes of climate change in Lupane

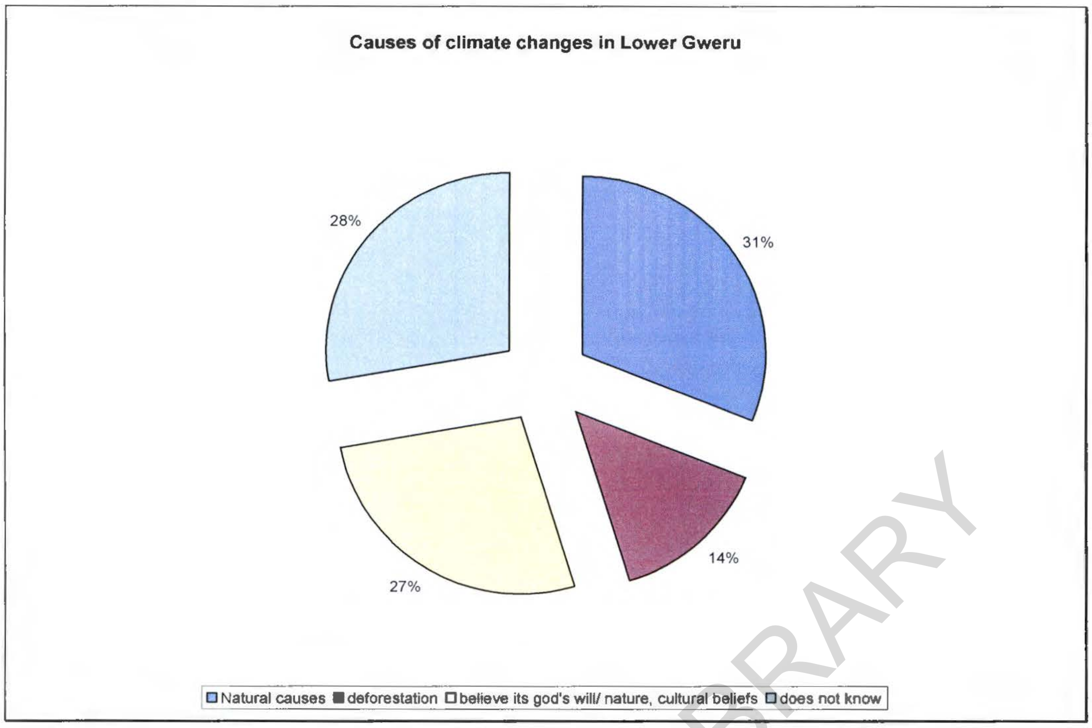


Figure 30: Perceptions regarding causes of climate change in Lower Gweru

5.3.1.3 Perceptions of farmers regarding climate variability and change and their causes (case studies)[15]

Having focused on farmers' perceptions with regards to variability and change and causes of these changes in climate in sections 5.3.1.1 and 5.3.1.2, this section presents in-depth cases studies illustrating these perceptions. This section presents case studies from Lupane and Lower Gweru in Zimbabwe and Monze in Zambia.

- *The case of Ellen Sibanda*

Ellen Sibanda (79 years old) resides in Mathonsi village in Nyama ward, Lower Gweru. She indicated that over the past five years, rains have become unpredictable as they no longer start at the expected time around October but rather, in November. Within the same period, temperatures have changed and they have also started experiencing prolonged winters into September. She further highlighted that these changes have been caused by the exodus of people to churches and the abandoning of coordinated traditional rituals, which were an integral component of the way of life of these people in Lower Gweru. Traditional rites that were conducted before have ceased. They used to go to *Matonjeni* (a traditional sacred grove

[15] In-depth interviews were conducted with the household heads (January 2009) for these and other in-depth case studies highlighted in this chapter

in the bush specifically preserved for traditional rites) to ask for rains from God through their ancestors. Ellen said, *'We used to play drums at Matonjeni to thank God for looking after us and for providing rains, no matter how little. We also at the same time asked for more rains in the coming season. This is why we had good rains in the past. Now, the church has taken over this role and now, no appeasement is granted to our ancestors'.* Ellen therefore suggested that God is angry and has decided to punish people; hence these negative changes in climate. Asked if there were any other reasons for climate changes she said that she thought that something had gone wrong in the oceans somewhere but still attributed this to the wrath of God and ancestral spirits.

- *The case of Busisiwe Mbangwa*

Busisiwe Mbangwa (34 years old), who is a widow and resides in Lupane, highlighted that rains have become unpredictable in the past 6 years. She emphasised the high incidence of excessive rains which she said was a recent phenomenon dating back to the last three seasons. Busisiwe also indicated that there has been an increase in dry spells over the years since around 1998 and that there is now a high incidence of winters which prolong until September, a change which she had noted for approximately the previous consecutive four years. When asked what she thought was causing these changes in climate, she indicated that God was angry and was punishing Zimbabweans for the political unrest that had been in the country for a number of years. She even cited what she called 'endless talks' (*kutaurirana kusingapere)* that were going on between political leaders in Zimbabwe at that time and gave this as an example of the cause of God's anger. Busisiwe remained pessimistic about the future, suggesting that *'If nothing is done about the current political unrest in this country, then we will continue to experience bad seasons as God is punishing us'.*

- *The case of Jobert Muzyamba*

Jobert Muzyamba lives in Muzyamba village in Monze and is 45 years old. He indicated that he had started noticing a change in precipitation around 1992, before which there was predictability of the rains, characterised by good seasons. He highlighted that rains were now less predictable and characterised by a late onset. Jobert reported that before 1992, the rains came in October but now they do not receive the first rains until it is mid-November. Although he indicated that he had not witnessed changes in temperature, he had noted excessive rains and floods in 1989 and 2008 respectively. These bad experiences with floods were compounded for him and his neighbour by the fact that they reside within the banks of Magoye River. Jobert emphasised the increase in climate variability as having started around the same time that President Chiluba got into power. In his own words, Jobert said, *'President Chiluba is the one who came with the high variability in precipitation. Before his leadership, this variability was minimal and we had plenty of food from our fields.'* Jobert associated this descendancy of Chiluba to power with the beginning of changes and variability in climate.

The case studies cited in this section suggest that farmers do not only associate changes in climate with natural factors, but also with social and spiritual factors. The implication is that when there are political, social and economic problems in a country, farmers tend to link them to climate change. Essentially, the cultural context and spiritual world view play a critical role in shaping farmers' perceptions and attitudes, a factor which may cloud farmers' consciousness of the negative effects of human activities on the earth. Farmers in Lower Gweru and Lupane link the political crisis in Zimbabwe at this time and the decline of social and cultural practices to the variability in climate.

Similarly, a farmer in Monze associates the beginning of climate variability with the descendancy of Chiluba into power. The period of his leadership period was marred with controversy and linked to economic problems in Zambia during this period. Moreover, what is emerging is the idea that we cannot disassociate climate change from the political, social (including the cultural and spiritual realms) and economic context. Farmers try to make sense of what is happening in their environment based on the socio-cultural framework in which they operate. However, it is of concern that farmers fail to associate climate variability and change with human activities and rather blame this variability on ancestors. This concern is based on the assumption that if farmers are aware of the extent to which activities such as deforestation may alter the natural processes, these farmers may consider taking remedial action.

5.3.2 MULTIPLE STRESSORS

5.3.2.1 Perceptions regarding other stressors among farmers

This section discusses farmer perceptions of a host of other stressors that compound climate change impacts. In previous research, risk elements have been considered to include both climate and non-climate risks such as droughts, floods, macro economic conditions, crop failure, crop and livestock pests and diseases, input supply and pricing fluctuation, among others. Scholars have also documented these and other risk elements (Campbell *et al.*, 2002; and Moriarty & Lovell, 1998). This section further displays how farmers view climate change among other disturbances through matrix scoring and ranking.

There is a general similarity in the stressors that were identified by farmers in all the four districts (see Table 13). These include constraints for increasing agricultural production, such as lack of capital to purchase agricultural inputs, implements and chemicals for crops and livestock. In addition, farmers in these districts indicated that inadequate draught power also inhibits their capacity to maximise on crop yields. Loss of cattle due to disease has led to limited draught power, which has reduced their ability to prepare larger pieces of land. Further compounding these challenges, farmers in all districts are faced with a lack of appropriate seed varieties and improved seed. Shortage of water for domestic use is another challenge that farmers in all districts have had to contend with. Also a cause for concern is the high incidence of HIV and AIDS in both countries, although in Monze and Sinazongwe, the problem has been alleviated by the availability of Anti-retroviral Therapy (ART) and food assistance for the chronically ill. What is emerging from the findings is that there is weakened government capacity in both Zimbabwe and Zambia districts in terms of provision of basic services to farmers. There was mention of non-functional dip-tanks and boreholes due to lack of maintenance. This would reflect the expectation that for substantial change to occur in the agricultural sector, it would need to be at least partially subsidised by the public sector (Wehbe *et al.,* 2006).

While there is a convergence in the challenges faced by farmers, there are problems that are unique to each district. For Monze and Sinazongwe, farmers are faced with low pricing for both crops and livestock. For crops in Sinazongwe, they are concerned with the low prices that they have had to sell their cotton and vegetables for. Low livestock prices are imposed on them by buyers who take advantage of them knowing that because they are poor, farmers will undertake the transaction as they need the money desperately.

In addition, the type of cattle breed in the area is too small for them to realise higher prices. Improved breeds that were introduced for them by government were unable to adapt. The weakening of government capacity in Zambia districts is further displayed by the diminishing of credit facilities from government in Monze since 1999. Lack of access to credit facilities has been a major set back for these farmers in acquiring the much needed inputs. The little inputs accruing from the facility were unevenly distributed.

What is also emerging is that there are more challenges that are unique to Lupane and Lower Gweru than those that are unique to Monze and Sinazongwe. In addition to the common problem of lack of capital to purchase inputs in both countries, farmers in Lower Gweru and Lupane have to further contend with the unavailability of these inputs on the market and late supply of the same inputs. By the time farmers get the inputs, they would have missed the rains. More compounding is the fact that these inputs are now coming from government and farmers only get them on the basis of their political affiliation (gathered in FGDs), meaning that in the end, some of them lack access to inputs completely.

What compounds these challenges is the lack of maintenance of roads and bridges in Lupane and Lower Gweru. In this respect, farmers in Lower Gweru highlighted that when they do manage to get some of their produce (the rest goes bad when they are in the process of finding transport) to the market after struggling with transport problems, the money that they get from their sales loses value fast within a period of one day due to hyper-inflation. The greater proportion of the income is also swallowed by high transport costs. As a result, these farmers have had to contend with a drastic reduction in income and food availability more than farmers in Monze and Sinazongwe (see Figure 31).

It is emerging that stressors in the different districts directly relate to specific economies of these districts and these farmers' livelihood strategies. For instance, although there have been problems related to livestock in all districts, most of the stressors highlighted by farmers in Sinazongwe and Lupane are related to livestock issues and this underscores the importance of livestock in the economy of these districts. In addition, both Sinazongwe and Lupane farmers highlighted that they experienced shortages of veterinary chemicals that were important for their livestock. The same is somewhat true of Monze where diminished dipping facilities were identified. It has already been highlighted in Chapter Four that the economies of these districts are livestock based and Monze also falls within the Southern Province of Zambia, which has the largest livestock population in the country. Veterinary services in Lupane also diminished and this had a negative effect on the well-being of their livestock, which were affected especially during the rainy season by a plant that kills cattle (farmers indicated that the local name for this plant is *mkhawuzane* but could not give the English name for this plant).

While there is evidence from the survey to show that farmers in Lupane and Lower Gweru have less access to weather information than farmers in Monze and Sinazongwe (see Figure 25), it is surprising that farmers in the former did not cite this as one of their stressors in FGDs. This says a lot about prioritisation of stressors by farmers. Although some farmers in Monze reported that there has been a slight decline in accessibility of weather information, the greater proportion indicated that they still have access to this information.

Table 13: Multiple stressors by District

Monze	Sinazongwe	Lower Gweru	Lupane
Lack of financial capital to purchase agricultural inputs	Imposed low livestock prices by buyers	Late supply of inputs	Lack of chicken feed
Erratic rainfall	Lack of improved cattle breeds	Lack of capital to buy inputs and farming implements	Lack of a bridge for the major river
Inadequate draught power due to a high frequency of livestock diseases	Low market price for vegetables	Inappropriate seed being supplied	Unavailability of inputs
Dams quickly dry up-there are no running rivers in the area	Streams and boreholes dry up early	Lack of transport to market produce	Lack of capital
Few dams for livestock watering	Pests and diseases in crops (vegetables)	Climate variability (Erratic rains, frost, drought)	Inadequate farming implements
Non- functional dip tanks	Floods and droughts	Inadequate draught power	Low soil fertility
Limited knowledge with regards to farming	Lack of money to meet charges for vet services	Unavailability of chemicals for crops	Limited knowledge on farming
Low selling prices of crops and livestock	Lack of improved seed varieties	HIV and AIDS	There are few mills and are far away
HIV and AIDS	Limited draught power and farming implements	Crops destroyed by livestock	Climate variability (low/excessive rains)
Limited access to credit facilities	Shortage of livestock drugs	Bad roads	Lack of pesticides/chemicals
Untimeliness of weather forecast information	Human diseases e.g. malaria, diarrhoea and HIV/AIDS	Lack of irrigation equipment	Inadequate draught power
Reduced access to information on weather forecasting		Unavailability of drugs in clinics	Shortage of water for domestic use
		Unavailability of water for domestic purposes (Non-functional boreholes)	Diminishing veterinary services

Source: FGDs in 2008

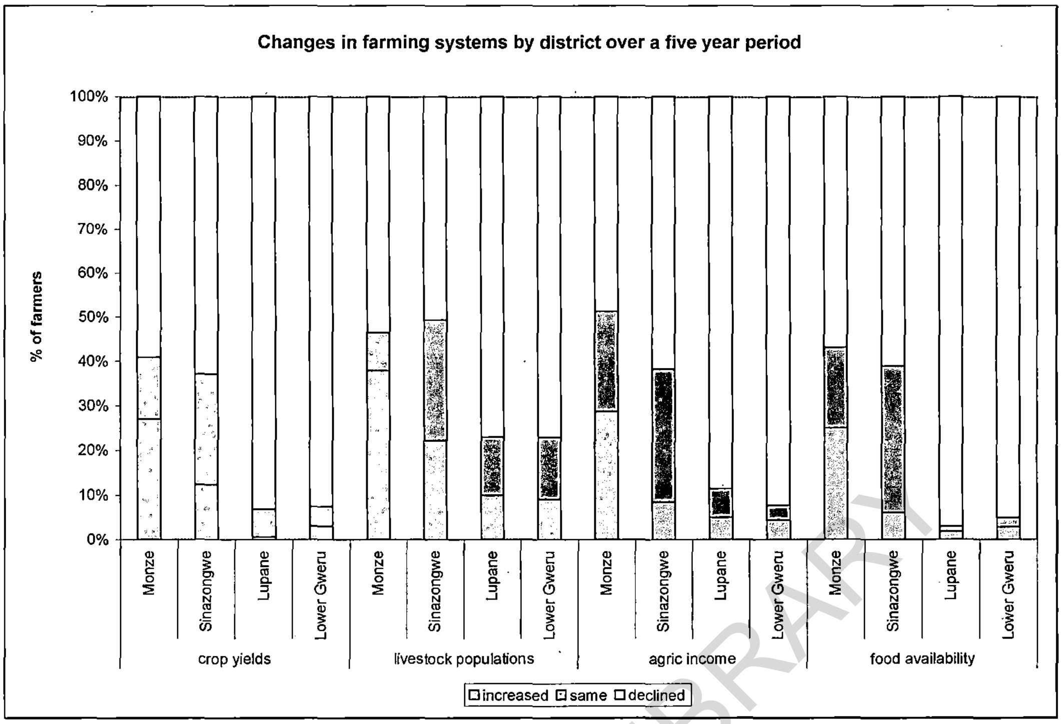
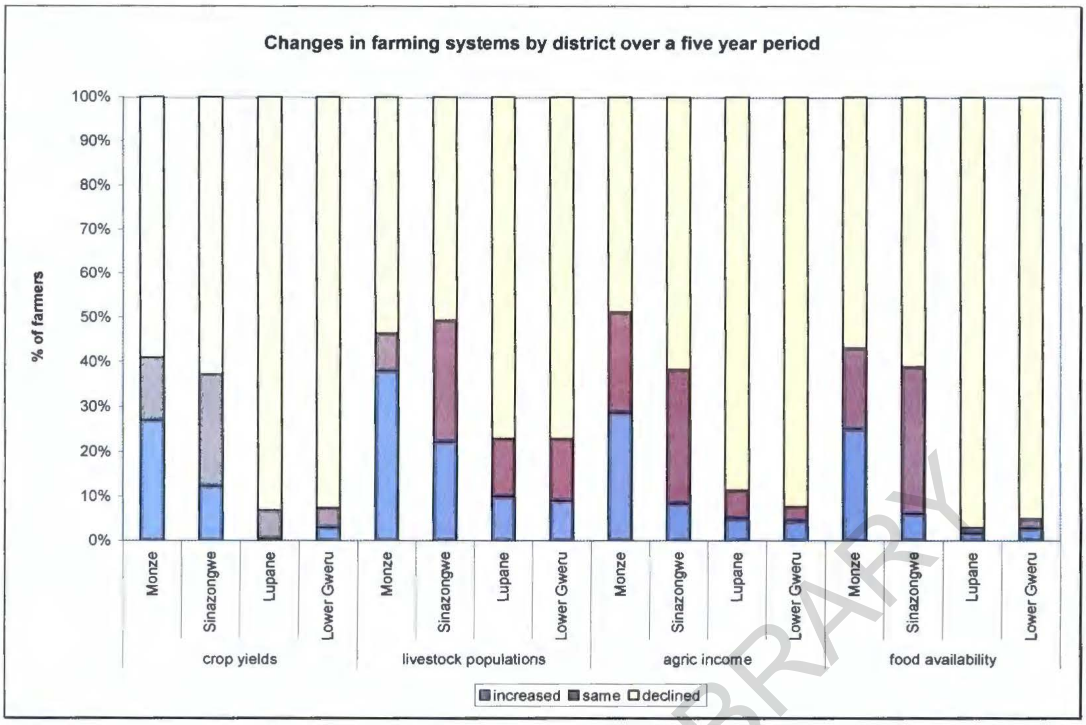


Figure 31: Farming systems changes due to climate variability and change in the study areas by district

In Sinazongwe, farmers were apathetic about weather forecasts and indicated that they did not see the difference between receiving and not receiving weather information even though they had been receiving some of the information. The fact that Monze farmers highlight reduced access to weather information as a stressor even though most of them still have some access gives an indication that they are aware of and acknowledge the importance of weather forecasts in farming, since they are more into crop cultivation than Sinazongwe farmers.

5.3.2.2 Farmers' perceptions regarding climate change in relation to other stressors

The above background (section 5.3.2.1) supports the concept of 'double exposure', which refers to the fact that regions, sectors, ecosystems and social groups will be confronted both by the impacts of climate change and other factors that are not climate-related (O'Brien & Leichenko, 2000). It was therefore envisaged as important for this study to factor in how farmers regard climate change as an obstacle to their livelihoods among the multiple stressors that they had identified, in order to put into context their perceptions of impacts from these changes. In this regard, a matrix scoring and ranking exercise was facilitated for farmers. In addition to showing the magnitude of differences between a set of alternatives, the



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It is evident that while there is a multiplicity of stressors that bedevil smallholder farmers in all the four districts in Zimbabwe and Zambia, climate variability and change in its different forms such as erratic rains, frost, droughts and floods are the most critical given that it was ranked first by farmers in all the sampled districts (see Tables 14 to 17). There was consensus from farmers' reports in group discussions to the effect that while there are a multiplicity of challenges that they have to contend with, farmers still find that most of these challenges emanate from the recent changes and variability of climate. This is consistent with findings from a study done by Thomas *et al.* (2007), that while climate does not operate in isolation from other factors, it does play a significant role in how people attempt to shape their livelihoods for the future. Farmers suggested that constraints such as lack of capital to buy food and agricultural inputs, shortage of draught power, imposed and low livestock prices and pests and diseases for crops and livestock, among others, are linked to climate variability and change (see section 5.2.3 for a detailed presentation of impacts from climate variability and change). For Lupane and Lower Gweru, this finding is consistent with the assertion by the IMF (2003) that the more recent difficulties with governance, mismanagement and inflation in Zimbabwe, for example, were not anywhere near as problematic at the time of the drought in 1992/3.

Table 14: Consideration of climate change with regards to other stressors in Monze

Stressor	Food insecurity	Loss of income	Insecure livelihoods	Total	Rank
Erratic rainfall	20	10	18	48	1
Lack of capital	10	20	15	45	2
Drying up of water sources	12	14	13	39	3
Few dams	10	15	8	33	4
Shortage of draught power	15	10	7	32	5
Lack of knowledge	9	12	10	31	6
Non- functional dip tanks	6	4	10	20	7

Table 15: Consideration of climate change with regards to other stressors in Sinazongwe

Stressor	Loss of income	Food insecurity	Total	Rank	Stressor
Floods and droughts	20	20	40	1	Floods and droughts
Imposed livestock prices	15	17	32	2	Imposed livestock prices
Lack of improved cattle breeds	20	10	30	3	Lack of improved cattle breeds
Not able to meet charges for vet services	17	8	25	4	Not able to meet charges for vet services
Pests and diseases for	15	6	21	5	Pests and diseases for

vegetables					vegetables
Streams drying up early	10	5	15	6	Streams drying up early
Low market price for vegetable	5	5	10	7	Low market price for vegetable

Table 16: Consideration of climate change with regards to other stressors in Lower Gweru

Stressor	Loss of crop yield	Loss of income	Insecure livelihood	Total	Rank
Climate variability (Erratic rains, frost, drought)	18	16	16	50	1
Shortage of drugs in clinics	16	16	16	48	2
Late supply of inputs	14	16	14	44	3
Lack of transport to market produce and bad roads	10	18	12	40	4
HIV and AIDS	10	10	14	34	5
Lack of draught power	12	10	6	28	6
Stressor	Loss of crop yield	Loss of income	Insecure livelihood	Total	Rank

Table 17: Consideration of climate change with regards to other stressors in Lupane

Constraints	Food security	Income generation	Total	Rank
Climate variability	20	20	40	1
Unavailability of inputs	15	10	25	2
Lack of farm implements	10	11	21	3
Lack of livestock chemicals	10	10	20	4
Low soil fertility	5	5	10	5

5.3.3 IMPACTS OF CLIMATE VARIABILITY AND CHANGE

It has been highlighted in Chapter Two that although adverse effects of climate change are projected to predominate for much of the world, particularly in the tropics and subtropics (IPCC, 2001 & 2007), it is important to engage in a discussion on positive and negative impacts from climate change. This was based on the assumption that farmers may be able to capitalise on the positive aspects and advantages from climate changes to improve their livelihoods. In this regard, this section also presents findings on positive impacts from climate induced droughts and floods/excessive rains. While farmers' perceptions of changes and variability highlighted in section 5.3.1 have been centred on a wide range of climate parameters, this section isolates and discusses results on impacts from climate change induced droughts and floods/excessive rains as these were the two climate parameters that were mentioned most by farmers. The impacts have been categorised into four themes emerging from farmers' responses in the various data collection exercises, namely, crop yield, health, water and the socio-economic context.

5.3.3.1 Negative impacts of climate change induced droughts

Farmers in all the four districts are mostly concerned about disruptions to their farming systems more than they are concerned with any other disruptions that may not be directly related to crops and livestock (see Figure 32). Farmers' perceptions of negative impacts that are dominant are on crop yield and livestock well being. Farmers also highlighted impacts on water resources, presumably because water is more critical in agriculture than in some other economic sectors. It is interesting to note that impacts on the socio-economic status of farmers are mostly dominant in the study districts in Zimbabwe; particularly those in Lower Gweru (see section on Impacts of drought on the socio-economic status).

1. Impacts of drought on crop yield

In all the districts in Zambia and Zimbabwe, it was perceived that due to droughts, most crops had dried up, a factor which led to reduced crop yield. In both countries, the major consequence of a reduction in cop yield during this period was food insecurity.

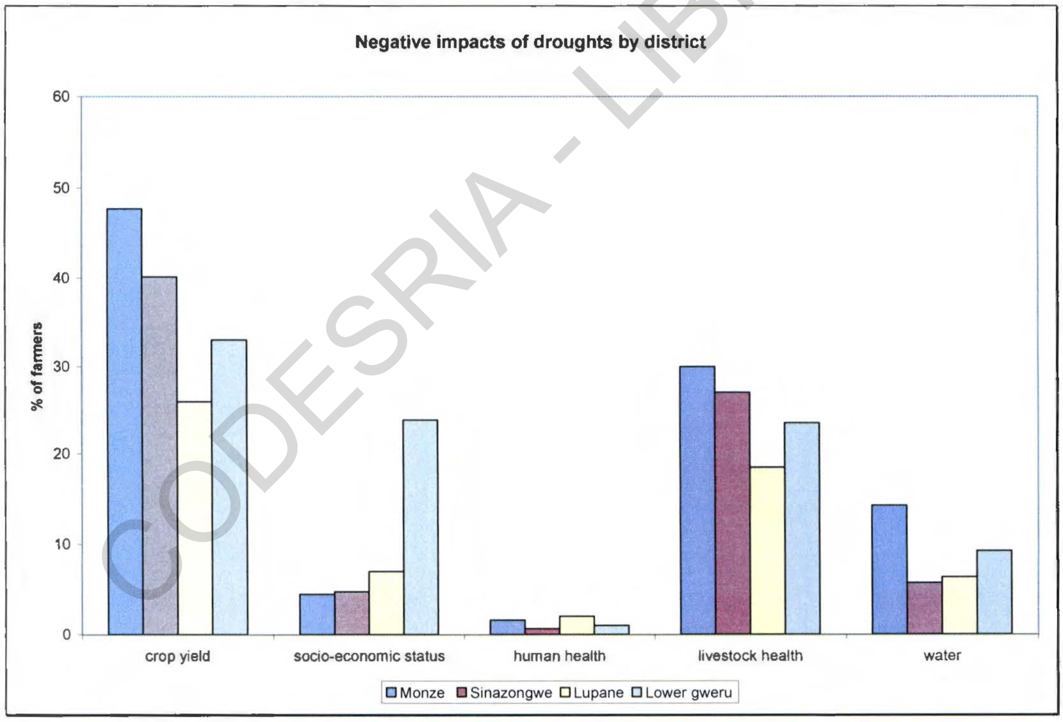

Figure 32: Perceptions of negative impacts of droughts on yields, water, the socio-economic status and health by district

A case of desperation was cited in Sinazongwe where a grain storage building was destroyed by a rowdy crowd of villagers who demanded to be given this grain, citing that they could no longer look at the grain and not be able to give it to their families. Yield reductions of a similar nature were recorded during the severe drought of 1991/92, when it was less than half that of 1990/91. In the seasons 1972/73, 1979/80, 1981/82, 1983/84, 1986/87, 1993/94 and 1994/95, significant shortfalls in maize yield were also recorded and these seasons were characterised as having below normal rainfall by the Zambian meteorological department. Essentially, drought has been the biggest shock to food security in the country during the last two decades (MoA, 2000 and Muchinda, 2001).

2. Impacts of drought on the socio-economic status of farmers

Many of the drought impacts highlighted by farmers transcend the climate dimension and are clearly played out within the context of other pressures and disturbances on livelihoods, even though the focus of group discussions was explicitly on climate events. Farmers stressed that these impacts are largely as a result of droughts that have occurred.

There is a general trend on the impacts that farmers had witnessed from droughts. Farmers in the four districts considered themselves to have been impoverished by these droughts as they no longer had an income from crop cultivation as before, having had to either restrict or stop selling produce. This poverty manifested in the form of them no longer having money to send their children to school, culminating in a lot of school drop outs. In this regard, young men in Monze and Sinazongwe and Lupane and Lower Gweru had resorted to crime to make a living for instance by stealing crop produce from neighbours' fields and livestock. Stock theft was especially reported in Lupane and Sinazongwe. Farmers added that the reduction in cattle numbers was exacerbated by the disposing of livestock through sales in order to meet household food requirements, particularly in Sinazongwe district. Survey results indicated that livestock sales had gone up to 49% in Zambia districts and 48% in Zimbabwe districts in drought periods. This has negative implications for farmers since livestock is critical for draught power and various other uses.

Also as a result of this poverty in drought periods, the social fabric was breaking as it was no longer the norm to assist each other as neighbours in times of need. It was revealed in in-depth case studies that farmers are now even embarrassed to ask for assistance from their neighbours when these farmers know that their neighbours have too little, which is not enough for their own families. Previous research has highlighted the important role that social and kinship networks play in sustaining households in times of need (Drimie & Gandure, 2005). While farmers used to engage in reciprocal work parties, these farmers have stopped as they no longer have adequate food and money to sustain these activities, which would lessen labour requirements and address lack of draught power. This is not unexpected in Zimbabwe where economic realities may call for individualism, that is, limited resources and high prices of basic commodities may mean that households cannot share with outsiders. In both countries, domestic disputes were also said to be on the increase and leading to broken homes. For instance, in Sinazongwe, there were cases of wives who were leaving their impoverished husbands to go back to their own families who were better resource endowed. In such cases, these women never returned to their husbands.

Despite the highlighted convergence, there are impacts that were reported by farmers in Zimbabwe districts, which were not perceived in Zambia districts. In Lupane and Sinazongwe, migration - both internal and external - was considered to be an impact of drought. Migration was reported to be on the increase in drought periods due to food insecurity. In Lower Gweru district, farmers were migrating to engage in gold panning in order to supplement household income. In both Lupane and Lower Gweru, farmers were migrating to other countries such as Botswana, South Africa and the UK to search for a living. Most of these migrants are the youths that have left school and are unable to secure employment. The matrix scoring and ranking presented in Tables 15-18 indicate that according to farmers' perceptions, climate variability has been the major constraint to food security, reasonable standard of living and income generation for these farmers.

Migration was cited as having led to a number of broken homes and a sharp decrease in household labour, a factor that they considered to have also contributed to reduced yields and leading to chronic illness, which farmers used as a proxy for HIV and AIDS. Subsequent deaths were also considered to have caused an increase in orphan incidence. This finding is similar to a study done in Sekhukhune district in South Africa where migration was also considered to have contributed to the high prevalence of HIV and AIDS (Ziervogel & Taylor 2008). Meadows (2005) indeed confirms that the virus is opportunistic and is likely to increase in the event of the intensification of other climate-related stressors, such as reduced food security on vulnerable populations. Furthermore, there were reports of governments reneging on relief projects during droughts in the districts in Zimbabwe. In the same districts, a reduction in crop yields led to food shortages and consequently increases in prices of basic food commodities.

What appears to be emerging is that farmers interpret droughts in terms of their experiences during such periods. These experiences are social and economic rather than purely measured in rainfall deficits. There is further evidence from case study research in Zimbabwe to support this point (Gandure, 2005). The implication in the cited impacts is that food insecurity due to droughts has far reaching impacts that may leave households in a cycle of poverty and results suggest that the situation for Lupane and Lower Gweru in Zimbabwe is more desperate than for Monze and Sinazongwe in Zambia.

3. Impacts of drought on health

Human health

Farmers resorted to using water from dirty swamps for drinking purposes due to the unavailability of water for domestic use, which reportedly caused diarrhoeal diseases. Under normal circumstances, farmers fetch drinking water from deep wells, most of which are located within their homesteads. Farmers indicated that swamps take longer to dry up in drought years. This was reported to have caused general poor health in a number of households, more so in Sinazongwe and Lupane with cholera identified in the former and malaria in the latter. Previous research findings in Zimbabwe have revealed that climate change associated diseases in Zimbabwe are cholera, dengue fever, yellow fever and general morbidity. In the same context, access to potable water and sanitation in Zambia is very low during droughts, causing an increase in the frequency of epidemics and enteric diseases (Chigwada, 2004 and ZINC, 1998). Both Lupane and Lower Gweru farmers cited malnutrition in children as having risen during drought periods due to high food insecurity levels. Farmers in Monze also attributed the emergence of big rats that they thought were coming from Tanzania, and which for this reason they named *Tanzania rats,* to drought.

Livestock health

In all the four districts, farmers indicated that there was an acute shortage of water for livestock during drought periods. This led to a marked decrease in the quality of pastures. For instance in Zambia, farmers in Mujika reached a point where they would temporarily migrate to areas where they could get pastures and water for their livestock. This result is consistent with a finding from research done in South Africa's rangelands (Meadows & Hoffman, 2003; Puigdefabregas, 1998 and Vetter, 2009) that vegetation change triggered by drought often results in reduced agricultural productivity, for example a loss of perennial shrubs or grasses. This is the case as livestock production is clearly dependent on the productivity of the associated vegetation of these rangelands (Meadows, 2005). In turn, poor quality pastures and limited availability of water reduced the amount of draught power that could be provided by livestock. Moreover, this was compounded by the fact that farmers can no longer afford to hire labour to supplement the little draught power available. It has been highlighted that at a given time, a reduction in precipitation would be likely to reduce the income of large livestock farms by about 9% (approximately US$5 billion); due to a reduction both in stock numbers and in net revenue per animal (Seo & Mendelsohn, 2006a & 2006b).

Livestock diseases were on the increase during droughts. In Zimbabwe's districts, diseases that were identified include foot and mouth, anthrax, black leg and lumpy skin. As a result, a number of livestock deaths were said to have occurred. There is literature to support these assertions by farmers. Outbreaks of anthrax are often associated with alternating heavy rainfall and drought, and high temperatures (Parker *et al.,* 2002). Blackleg, an acute infectious clostridial disease, affects mostly young cattle, and disease outbreaks are associated with high temperature, droughts and heavy rainfall (Hall 1988). In the same context, Sinazongwe farmers' livestock had to share the remaining dirty water with wildlife that also started moving close to homesteads in search of water. This fact was considered to have caused an increase in livestock diseases and deaths. Drought occurrences are also considered to have caused a reduction in wildlife through deaths in the past due to a reduction in water flows at the Victoria Falls (Chigwada, 2004).

4. Impacts of drought on fresh water availability

In Lower Gweru, water resources did not dry up. This finding is not surprising given the location of the district in a well watered region in Zimbabwe. This led to unavailability of water for domestic use and women had to walk long distances to fetch water for the household. Only farmers in Lupane district in Zimbabwe and Sinazongwe district in Zambia reported that they witnessed the drying up of vegetation during droughts. Findings are consistent with predictions which show that there will likely be an increase in the number of people who could experience water stress by 2055 in Northern and Southern Africa and that the greatest reduction in runoff by the year 2050 will be in the Southern Africa region. For Southern Africa, almost all countries except South Africa will probably experience a significant reduction in stream flow (Arnell, 1999 & 2004; De Wit & Stankiewicz, 2006 and New, 2002). This would affect ecological and economic processes which are to a greater or lesser extent, limited by water availability (Meadows, 2005).

5.3.3.2 Positive impacts of climate change induced droughts

In Lupane and Lower Gweru, there is a marked decrease in availability of labour to work in the fields when youths leave for neighbouring countries during droughts. However, remaining members of the household benefit through remittances that are sent back by their children and relatives. Farmers in Zambia indicated that when there are droughts, they become more hard working and enterprising, leading to diversification into non-farming activities such as petty trading and handicraft, which supplement the poor harvests that they get during these times. These activities have become a way of adaptation since farmers continue to employ these strategies even in good years. Remittances and livelihood diversification are considered to contribute significantly to the livelihoods of rural households as found in Sekhukhune district in South Africa (Ziervogel & Taylor, 2008) and in previous research in Zimbabwe (Drimie & Gandure, 2005 and Scoones, 1996). Essentially, it is emerging that these impacts also become adaptation strategies that farmers rely on.

5.3.3.3 Negative impacts of climate change induced floods/excessive rains

According to farmer perceptions, negative impacts on water are significantly less pronounced in floods and excessive rains than in drought periods in both countries (see Figures 32 and 33). However, livestock health and crop yields are still critical in both conditions. Farmers indicated that negative socio-economic impacts are still higher in Lupane and Lower Gweru than they are in Monze and Sinazongwe and this could emphasise the point that farmers measure impacts from changes in climate with their experiences. Therefore, it may be that perceptions of farmers in Zimbabwe districts magnify impacts from climate variability and change with socio-economic and political challenges that they are faced with.

1. Impacts of floods/excessive rains on crop yield

Similar to the impact of drought, it was reported in the four districts in Zambia and Zimbabwe that floods had led to very low yields due to water logging and leaching. For some farmers there was total failure of crops, particularly in Monze and Sinazongwe (see cases in section 5.3.2). In Zambia, crops were stunted due to floods and those that did reach maturity rot. Farmers in Monze indicated that water in the fields reached knee height. Some fields were swept away and others were silted, making it difficult for crops to reach maturity. Moreover, farmers in both countries did not get time to weed their fields as most of the time it would be raining. An example was cited in Monze when it rained heavily and continuously for eight days. In Sinazongwe, a lot of farmers resorted to eating wild fruit in order to supplement the little food that they could get. Research done in Ecuador similarly shows that during floods in 1998/99 there was total loss of harvests, which led to increased unemployment and a 10% poverty incidence (Stern, 2007).

2. Impact of flood/excessive rain on the socio-economic status of farmers

There are similarities in the way farmers were affected by floods in Monze and Sinazongwe and excessive rains in Lupane and Lower Gweru. During this period, roads were damaged and bridges collapsed in all districts except Monze. In Sinazongwe and Lower Gweru districts, this led to transport operators withdrawing services as they feared for the safety of their vehicles. This was compounded by the fact that feeder roads in Sinazongwe were impassable and farmers had to walk long distances to get transport to the city. Local retail shops ran out of the basic commodities in both districts and basic commodities became very expensive as it became increasingly difficult to bring them to the shops. There was a drop in school attendance in this district as bridges were destroyed. Moreover, farmers in Lower Gweru district were heavily affected as they subsequently failed to ferry their horticultural produce to the city.

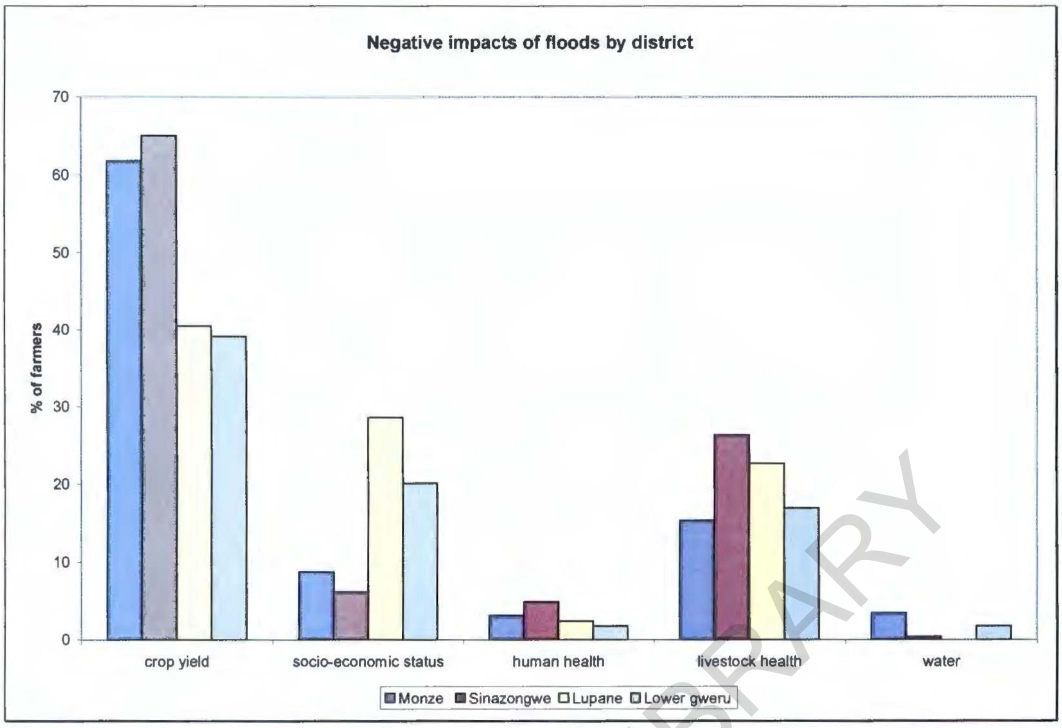

Figure 33: Farmers' perceptions of negative impacts of flood/excessive rains on yields, water, the socio-economic status and health by district

In this respect, early warning systems of extreme weather conditions cannot be overemphasised to ensure that farmers are warned in advance and take appropriate measures to deal with these floods. This is a major setback in Southern Africa, among other regions, where early warning systems and education programmes raising awareness of climate change are considered to be poor (Stern, 2007).

Furthermore, in all districts, some structures that were not strong were reported to have collapsed while others were easily swept away and some roofs carried away (see case studies section 5.3.3.5). Household property was damaged in the process. In Monze, some toilet buildings were also damaged. In Sinazongwe and Monze districts, some households sought refuge in schools and others had to move in with relatives and this was reported to be a serious disturbance as these relatives were facing problems of their own. In both districts in Zambia and Lower Gweru in Zimbabwe, people who tried to cross rivers were swept away and while young school children were reported to have died, some people were later rescued after being stranded in the river. In Monze, two people even died during this period as they tried to cross the river.

However, there were impacts that were unique to the two Zambian districts. Farmers reported that trees had also been uprooted during the flood. Schools' infrastructure was destroyed in heavy storms during this time. All these impacts would further affect the already impoverished farmers who have limited resources and household income from which to draw in these times. Financial costs of extreme weather events represent a greater proportion of GDP loss in developing countries, given the higher monetary value of infrastructure (Stern, 2007).

3. Impacts of flood/excessive rain on health

Human health

Flood waters contaminated sources of water for domestic use in Monze and Lower Gweru and this led to diahorreal diseases such as cholera and dysentery. People (especially children) developed sores on their feet and between their toes as they walked in water barefoot for a protracted period. There are similar findings from previous research which show that following the 1997–1998 El Niño event, malaria, Rift Valley Fever (RVF), and cholera outbreaks were recorded in many countries in east Africa (WHO, 1998). In the same context, although cholera has been around for a long while and periodically, there have been widespread outbreaks, the Zimbabwe Initial National Communication on Climate Change (1998) reinforces that cholera is one of the climate change associated diseases in Zimbabwe. In Zambia, floods have been found to increase the frequency of epidemics (Chigwada, 2004).

Malaria was reported to have affected households in Lupane, Lower Gweru and Monze during floods and excessive rains. This result is not unexpected as there were earlier predictions of increasing malarial trends, which were likely to become more pronounced as the climate changes. At that time, 80% of malarial incidences in Zimbabwe were linked to changes in rainfall and temperature (Freeman & Bradley, 1996; Hulme & Sheard, 1999; Loevinsohn, 1994 and WHO, 1998). Similarly, in a study done in Zambia, a simple linear regression revealed that between 1998 and 2005 malaria increased as rainfall increased in Chadiza and Mazabuka Districts in the Eastern and Southern Provinces respectively. Studies from elsewhere in Zambia also found that malaria incidences in wet years were considerably higher than in dry years. Particularly notable are the reductions in malaria during the 2002 drought (Chigwada, 2004).

Livestock diseases were reported in all the four districts with foot rot and blisters cited in cattle for Monze and Lower Gweru. Some of the affected livestock died as most of the concerned farmers could not afford costs of veterinary medicines to treat their livestock. Animal experts confirm that animals such as cattle, sheep and goats standing in mud or water for prolonged periods of time may develop foot rot (Navarre, 2006). Goats and cattle in Zambia also became blind as a result of floods/excessive rains. Although farmers were able to name some of the diseases affecting livestock after floods, they were not able to tell the name of the disease that causes blindness. The increasing disease incidence in livestock is an expected result as predictions for variability in rainfall in Africa show that increased precipitation of 14% would be likely to reduce the income of small livestock farms by 10% (approximately by US$ 0.6 billion), mostly due to a reduction in the number of animals kept (Seo & Mendelsohn, 2006a & 2006b). Moreover, it has been documented that increased precipitation as a consequence of climate change could increase the risk of infections in livestock and people (Baylis & Githeko, 2006). Livestock were also lost in Zambia as heavy floods swept them away in the pastures.

4. Impact of flood/excessive rain on fresh water

In Monze, wells were damaged and households had to dig new ones during excessive rains and floods. The overflowing of wells also meant that the water in these wells was no longer safe for drinking. Rivers were reported to have been silted in all districts after the floods due to widespread soil erosion. This finding on the siltation of rivers is corroborated by Rosenzweig and Hillel (1995:7), who assert that "extreme precipitation events" can cause increased soil erosion. The implication on smallholder farmers is that this would further affect the quality of soil for crop cultivation.

5.3.3.4 Positive impacts of climate change induced floods/ excessive rains

In floods, farmers in both countries reported that there is adequate food for livestock in both countries. During this time, pastures and vegetation tend to be green and of good quality and there is adequate water for livestock, which is good for general animal health. This is consistent with results from a study done in South Africa by Turpie *et al.* (2002), which highlights marginal to quite strong positive impacts of climate change in the larger livestock-rearing areas of the better watered east. In Mdubiwa, Lower Gweru, farmers mentioned that they normally have wells drying up fast in times of drought, but when there are excessive rains then these farmers have adequate water for domestic use and also for gardening in the wetlands which remain charged until the next rain season. The same applies to farmers in Monze and Sinazongwe who, after floods, carry out gardening activities throughout the year. However, it is important not to overemphasise this point as this positive effect tends to be offset by longer dry spells and, in short, a significantly more variable hydrological response (Meadows, 2005).

In addition, in-depth case studies in Monze revealed that since some farmers live on high ground, they get good yields for cowpeas and sweet potatoes at these times as floods do not affect the high ground. This then contributes to the income in the households while in wetter areas such as Nyama ward, excessive rains would destroy garden crops. Previous research has also shown where areas in the path of rain-bearing winds may benefit from increased rainfall (Rosenzweig & Hillel, 1995). Furthermore, reports indicated that during seasons when there are excessive rains, there is good fruiting of trees and households benefit from wild fruits. In excessive rains in Zimbabwe districts, crops that are planted late were considered to do well as they were able to reach maturity with the late rains. This ushers in the notion that access to weather information is critical for farmers so that they are able to take advantage of and offset the effects of excessive rains and floods. In Zambia districts, for those who lived within the vicinity of rivers, live fish were found near homesteads as they had been swept away from the rivers.

5.3.3.5 Farmers' experiences in the face of climate variability and changes

Sections 5.3.3.1 to 5.3.3.4 have presented findings on impacts that farmers have experienced due to climate induced droughts and floods/excessive rains. This section builds on these findings by presenting case studies that illustrate farmers' experiences during climate induced floods/excessive rains and droughts in Monze and Lower Gweru respectively.

- *The case of Nehemiya Hambuya*

Nehemiya Hambuya, who is 47 years old, is married and has nine children. He stays in Mujika village, Monze and this is also where he was born. Nehemiya started farming with his parents at the age of 19 but started to farm on his own in 1995 when he was 33 years old. Although he does not know the total amount of land that he holds, his land is not much and he used to rent land when the rains were more predictable and he had adequate draught power. Around 1991, he used to get on average, yields as much as 260 x 90 kg bags of maize. From around 1996, they started experiencing more and more dry spells and drought periods and his yields dropped to an average of 35 x 50 kg bags of maize on the same amount of land as before. These drought conditions also affected his livestock which were attacked by corridor diseases and teaks, subsequently affecting availability of draught power. He lost 20 cattle in a period of 10 years and now has no cattle, but one goat only. Nehemiya attributed this loss of cattle to corridor disease and teaks which were caused by the diminishing dipping facilities and availability of vaccinations. After this loss, he then decreased the hectare under cultivation and stopped renting land. The unavailability of draught power compounded the drought conditions, leading to food insecurity in his home, considering that he has a large family. Making the situation worse for Nehemiya was the reduction of the loan facility for inputs in 1999. The recent incidence of floods in Monze, according to Nehemiya, ushered in a further drastic reduction in crop yield. The plight of his family has worsened in the previous two seasons (2006/7, 2007/8) due to floods. For example, in 2007/8, he got no bags of maize after his crops did not germinate and those that did were stunted. The little maize that they could get they harvested as green mealies in order to feed the starving large family. Trees could get they harvested as green mealies in order to feed the starving large family. Trees around his homestead were uprooted by storms and it was difficult to walk around the home because of the floods which covered part of his home (see Photos 1 and 2). The roof of Nehemiya's main house was blown away during this time. Nehemiya indicated that '*although there were positive impacts from these floods, such as the availability of water for domestic use and livestock watering and the availability of fish around the homestead as water was over-flowing from rivers, negative impacts outweighed the positive ones by far. My household has been severely destabilised by these drought and flood occurrences so much that now I find it difficult to plan for agricultural activities for the next season, as before. I am also finding it increasingly difficult to feed my family.*'

Photo 1: Destruction of Nehemiya's house by floods

Photo 2: Water logging in Nehemiya's homestead after floods

❖ *The case of Mollie Dube*

Mollie Dube of Nyama ward, Lower Gweru, was born in 1946 and has been a widow for six years now since 2002. Mollie has six grown up children, some of whom are working in various towns around Zimbabwe and others in neighbouring countries. Her husband worked for the Ministry of Information in Gweru and she stayed in the rural areas all the time. Mollie's husband stopped working around 1998 when he fell ill and came back to the rural home to stay with his wife. At this point he was now farming with her. She attended school up to standard six where she says she learnt *'proper Oxford English'*. Both Mollie and her husband are originally from Lower Gweru so they both married locally. Mollie has experienced food insecurity due to excessive rains in the 2008/2009 season (see Photos 3 and 4) and droughts in the past years. Crop cultivation was her major source of income and this has meant that her income has gone down drastically. She used to sell her harvest to the Grain Marketing Board (GMB) but she has had to stop. For 10 years now she has not sold her harvest to the GMB. For her, problems brought about by droughts and excessive rains have been compounded by the death of her husband, who would finance agricultural activities in the farm and address the issue of lack of inputs. She no longer has enough money to buy inputs as her major source of income has been negatively affected. She further highlighted that commercial farmers who used to produce seed are no longer there and when seed is available it is extremely expensive, a factor which has been made worse by hyper-inflation in Zimbabwe. In addition, Mollie has become more vulnerable since the death of her husband as she has started to have her agricultural implements stolen as people are aware that she has lost her 'protector' (her husband). Although she owns seven hectares of land, she is only cultivating 1 ha due to this combination of constraints. Mollie can no longer afford to hire labour for her large piece of land as before. Ever since this time, she has been growing crops only for subsistence but has been failing to get any yield to last her until the season.

Photo 3: Water logging at Mollie's homestead after excessive rains

Photo 4: Mollie's stunted crop maize after excessive rains

The case studies highlighted in this section emphasise that in addition to climate variability and changes, farmers are faced with a myriad of other challenges, which worsen their predicament. Therefore, it would be naïve to attribute food insecurity solely to climate change, a factor which suggests that there is a need to understand the multiplicity of challenges that confront farmers.

5.3.3.6 Trends in crop production among farmers in the study districts

Food crops[16] grown in all districts include beans, groundnuts, cowpeas and sweet potatoes. Drought tolerant crops include millet, rapoko and sorghum. There is an indication that crop production has gone down over the past 5 years for all types of crop in both countries (see Figure 34). This has negative implications for food security considering the staple crop has the largest percentage reduction in crop production particularly in Lupane and Lower Gweru. This corresponds with predictions on Zimbabwe, which showed that maize production was expected to significantly decrease by approximately 11–17%, under conditions of both irrigation and non-irrigation (Agoumi, 2003; Magadza, 1994; Makadho, 1996; Mano & Nhemachena, 2006; Muchena, 1994 and Stige *et al.*, 2006). Figure 31 further illustrates that reduction in crop production is more apparent in Lupane and Lower Gweru for all types of crop than in Monze and Sinazongwe.

In addition, this is compounded by the fact that while cotton (a cash crop) has not been grown in Zimbabwe districts, it is one of the crops that contribute to income generation for these small-scale farmers and is well suited for Lupane district. While the highest reduction in crop production in Zambia districts is in the cash crop (50.4%), the least reduction is in food crops

[16] It was considered important to separate food and staple crops in this thesis. The staple crop for all the districts under study is maize. It was therefore important to understand changes in maize yields and implications for food security.

(30.4%). More disturbing is the fact that drought tolerant crops have also had a marked reduction in production, particularly in Lupane and Sinazongwe, yet these drought tolerant crops are supposed to cushion farmers, especially those in Lupane, against climate related causes of crop reduction.

While farmers indicated in group discussions that the major reason for the reduction in crop yields was climate variability, the reduced yield in Lupane and Lower Gweru for this period could have been compounded by Zimbabwe's plunge into economic turmoil, which started around 1997 (Gandure & Marongwe, 2006). As a result of the reductions in yield, farmers in both countries, but more so in Zimbabwe districts, also resorted to eating food that they do not normally eat, such as treated seed. Survey results indicated that 65% of the sampled farmers eat food that they do not normally eat, against 19% in Zambia districts, implying that the former are more hard hit than the latter. This may have negative implications on human health.

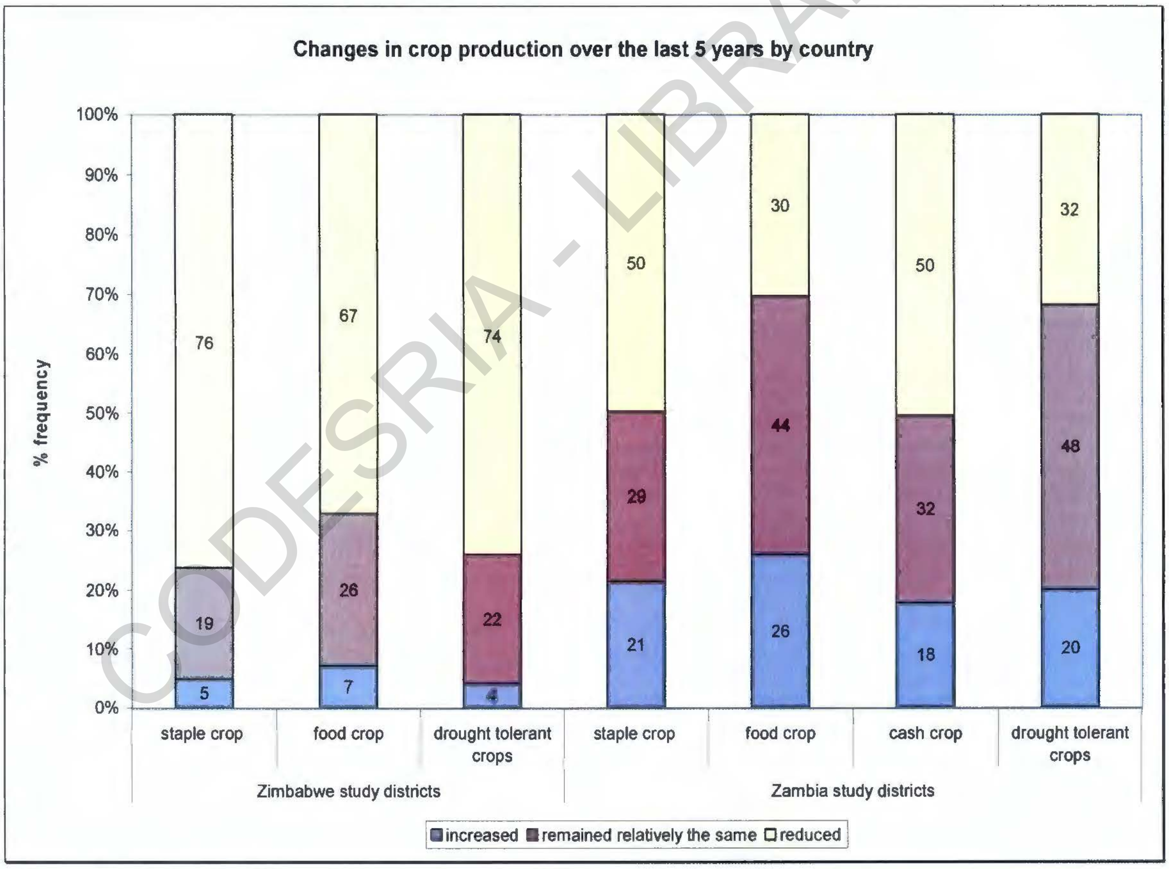

Figure 34: Changes in crop production over the past five years by country

5.4 STRATEGIES USED BY FARMERS TO DEAL WITH CLIMATE VARIABILITY AND THE SUBSEQUENT FOOD INSECURITY

While floods and droughts have occurred periodically in most societies, findings for this study have established that there has been an increase in climate variability as observed in extreme events such as floods, droughts and dry spells, among others. The most dominant of these occurrences are droughts and floods, the latter of which have been established to be an even more recent phenomenon. This variability has been noted especially in the past twenty years. In this regard, this section discusses strategies that farmers use in response to droughts, floods and subsequent changes in food availability. Furthermore, it is important to distinguish between actions undertaken only in times of variability of climate and those undertaken all the time. For this reason, this section also presents results of whether farmers undertake actions all the time or they use them specifically to deal with challenges brought about by climate variability. Lastly, in order to understand how farmers react to food insecurity, the third part of this section presents strategies that farmers engage in when there is food insecurity. Parallels will then be drawn based on the strategies that farmers use at different times in their respective locations.

5.4.1 RESPONSE STRATEGIES TO CLIMATE INDUCED DROUGHTS, FLOODS AND CHANGES IN FOOD AVAILABILITY

5.4.1.1 Strategies in response to droughts

Adoption of conservation farming methods is dominant in both countries during droughts (Figure 35 highlights the specific methods that farmers use). A strategy that is also used in these periods is the growing of drought tolerant crops and varieties, which is used more by Lupane (27%) and Lower Gweru (33%) farming households than by Zambia districts' households (see Table 18). Gardening and early planting are common strategies in both countries at this time although Monze (27%) and Sinazongwe (26%) farmers are more inclined to engage in gardening. When farmers in Zambia districts realise that there is less water for the season than normal, they concentrate more on off farm work, livestock rearing and crop diversification. In Monze, where crop diversification is the most dominant strategy, farmers indicated in FGDs that they diversify by growing sorghum and ground nuts and by growing drought tolerant and early maturing varieties from Pannar and Seed Co. For Lupane and Lower Gweru farmers at this time, the purchase of food is a common response. This is not surprising considering that lower yields have been received in these districts than in Monze and Sinazongwe.

Table 18: Response strategies during droughts by district

Response Strategy	Monze %	Sinazongwe %	Lupane %	Lower Gweru %
Adoption of Conservation Farming (CF)	29	19	27	23
Gardening	27	26	15	11
Grow drought tolerant varieties/crops	4	8	27	33
Early planting	9	6	7	10
Off farm/informal work	10	19	4	3
Livestock rearing	10	7	4	1
Crop diversification	10	2	0	3
Buy food	0	4	9	3
Other*	4	9	8	16

*digging shallow wells, use of OPV, eating wild fruits, decrease of hactarage, barter trade & migration in Zim study areas)

5.4.1.2 Strategies in response to floods/excessive rains

While adoption of conservation methods is somewhat maintained during flood periods in Monze and Sinazongwe (emphasising that this activitiy has been ingrained in these farmers' usual farming activities), it is intensified in Lupane (76%) and Lower Gweru (53%) during heavy rains, largely with the making of contours in Lower Gweru (Table 19). Gardening (cultivation of horticultural crops in wetlands) is also intensified at this time in Zambia districts and this could be the case as farmers take advantage of the fact that wetlands remain charged for a long time afterwards and they therefore grow crops throughout the year.

Table 19: Response strategies during floods/excessive rains by district

Response Strategy	Monze %	Sinazongwe %	Lupane %	Lower Gweru %
Adoption of CF	25	11	76	53
Gardening	37	29	9	2
Upland cultivation	9	16	7	23
Crop diversification	7	5	0	6
Early land preparation	10	1	5	5
Buy food	2	4	0	5
Off farm/informal work	3	20	2	0
Other	6	12	2	8

For instance, in Monze, they grow cassava after floods to supplement food reserves as they will have got very low yields. Gardening is therefore a critical strategy to deal with climate variability and change in Monze and Sinazongwe. Upland cultivation is a common response to floods in all the four districts but more so in Sinazongwe and Lower Gweru. Off farm work remains important at this time in Monze and Sinazongwe districts, specifically in Sinazongwe.

5.4.1.3 Conservation farming methods used

Considering that use of conservation farming methods is dominant as a response to both floods and droughts, follow up questions were asked to establish the specific methods that farmers use (Figure 35). All the methods, with the exception of winter ploughing and intercropping are mostly practiced by households in Monze district. Winter ploughing is most common in Lower Gweru and intercropping in Lupane. The growing of drought tolerant crops and varieties is the most dominant in all the districts, which is congruent with farmers' perceptions that precipitation has declined over the years. This also supports the notion that farmers respond to climate variability based on their perceptions of this variability.

In Sinazongwe, farmers plant drought tolerant crops such as millet, cotton, sorghum and cow peas, which they plant late in the season around January, in order to take advantage of the late rains that they now expect for each season. In Monze, they also plant late maturing varieties[17]. In Lupane, they grow sorghum, millet and mashamba *(amajodo)*. Use of crop residue is least common in Lower Gweru as these farmers indicated that in a bad season, farmers keep crop residue for stock feed and not for their fields.

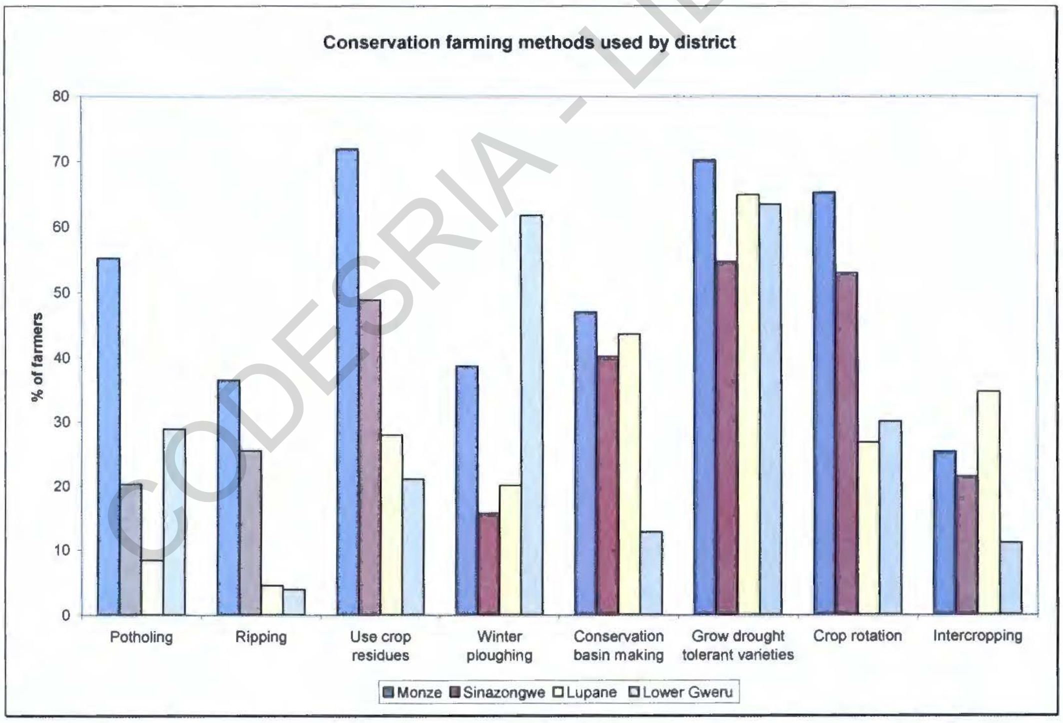

Figure 35: Conservation farming methods used by farmers in the study districts in Zimbabwe and Zambia

[17] Examples of the late maturing varieties used include MRI, 624, Seed Co. 701 and 709

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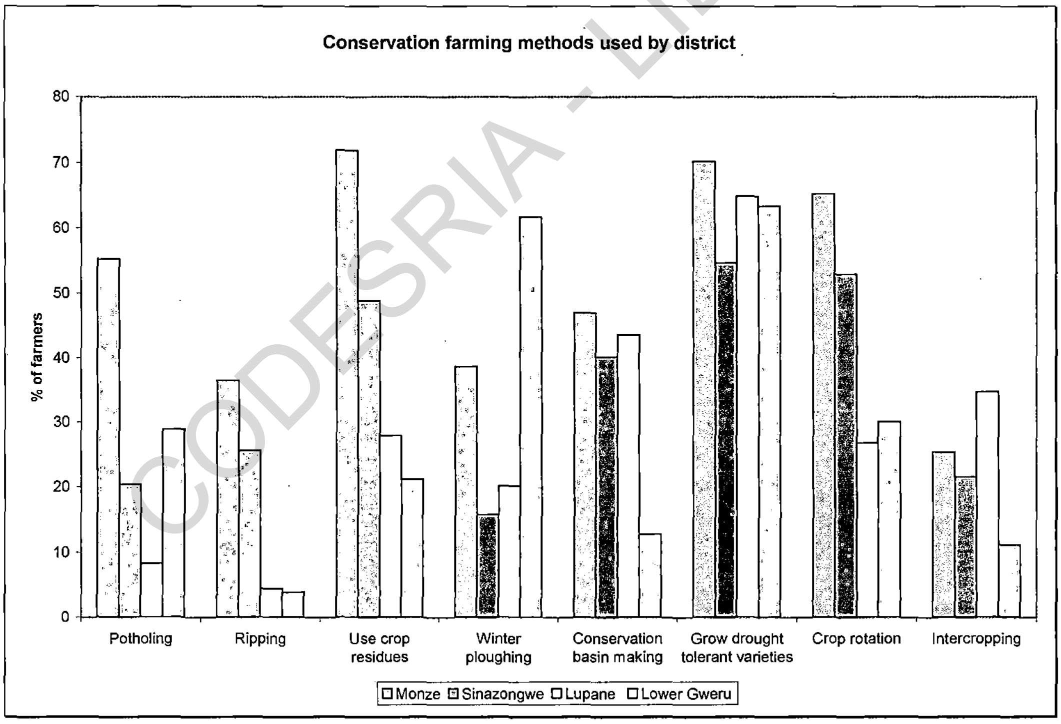

Figure 35: Conservation farming methods used by farmers in the study districts in Zimbabwe and Zambia

[17] Examples of the late maturing varieties used include MRI, 624, Seed Co. 701 and 709

5.4.1.4 Strategies in response to changes in food availability

Farmers highlighted that there is food insecurity that largely emanates from climate variability. It was therefore important to establish how they respond to this food insecurity. It is illustrated in Figures 36 and 37 that livestock sales, renting out land and the selling of firewood are the only strategies that are practiced more in Monze and Sinazongwe than in Lupane and Lower Gweru. The rest of the strategies highlighted in these figures are most dominant in Zimbabwe districts. This evidence suggests that farmers in Zimbabwe districts engage more in livelihood diversification than those in Zambia districts. This fact is not unexpected considering evidence from previous sections that Zimbabwe districts are harder hit with multiple stressors than Zambia districts. This contradicts the notion that vulnerable populations have little recourse in the face of food insecurity.

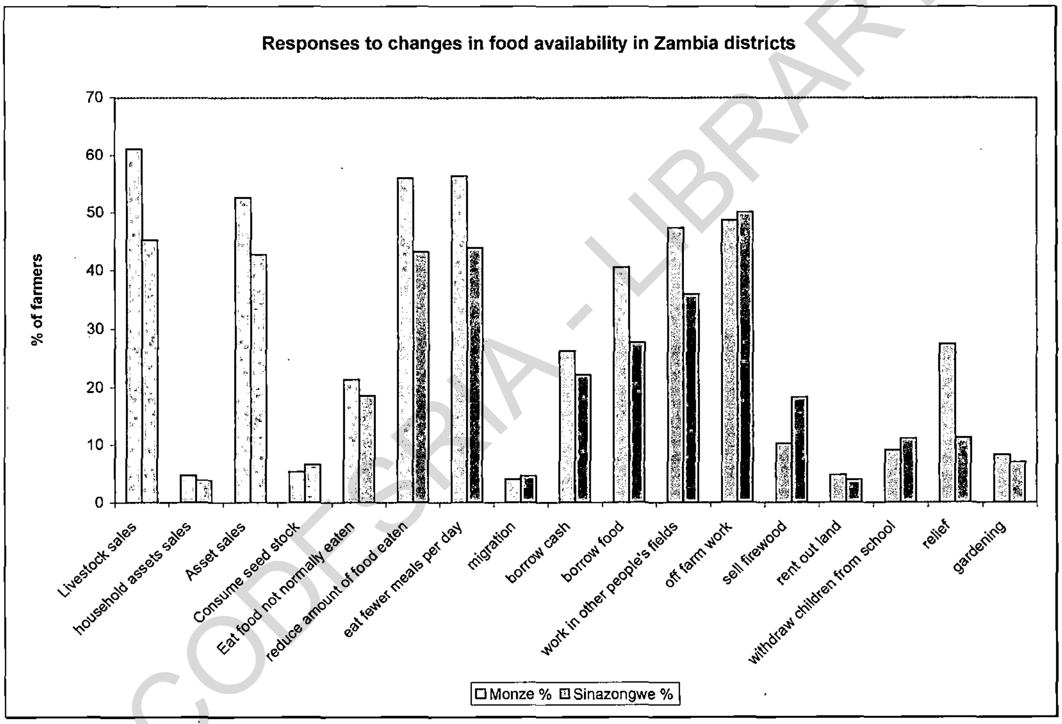

Figure 36: Responses to changes in food availability in Zambia by district

In addition, adaptations such as diversifying livelihoods are not responses unique to climate disturbances, and all are embedded in the full range of livelihood changing factors (Thomas *et al.,* 2007). Furthermore, households facing regular episodes of food insecurity have been found to develop complex strategies for dealing with these events (Liwenga, 2003; Reardon, Malton & Delgado, 1988 and Von Braun, Teklu & Webb, 1998). The implication is that their livelihoods are more vulnerable to production shocks than less vulnerable households and that there are multiple coping strategies available to them (Phillips, 2007 and Swift & Hamilton, 2001). Diversity, therefore, could have been used as an insurance mechanism in an unpredictable environment or can be a necessity in the face of immediate food insecurity (Hulme, 2001).

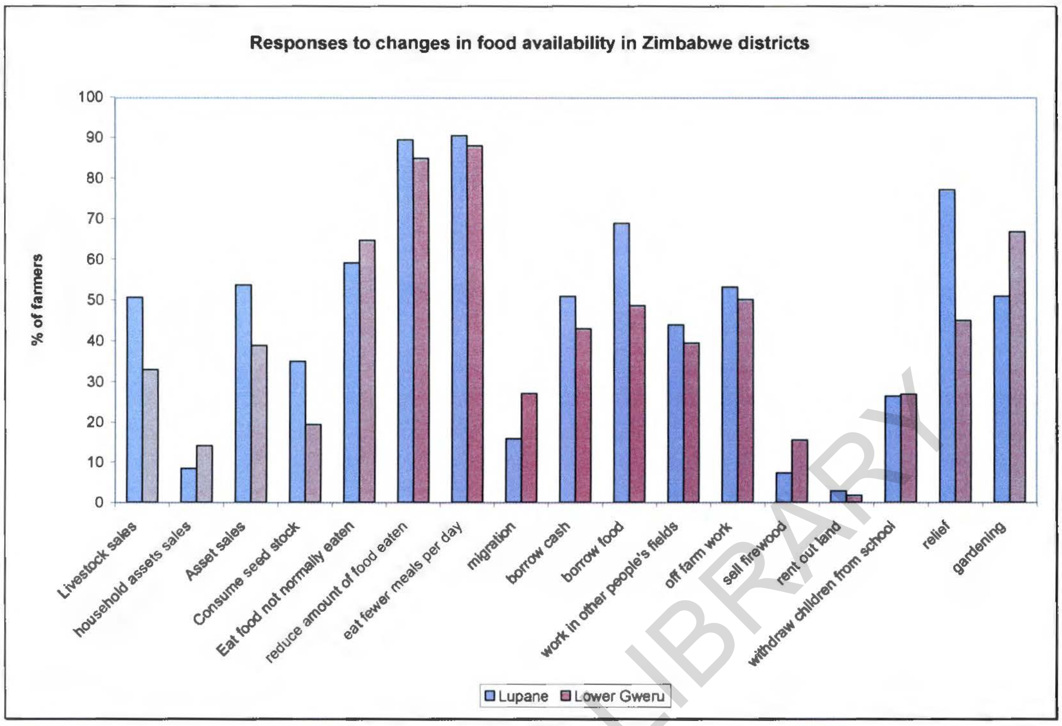

Figure 37: Responses to changes in food availability in Zimbabwe by district

Generally, strategies in response to changes in food availability are more diverse in Zimbabwe districts than in Zambia districts. While for Monze and Sinazongwe, income and consumption strategies are the most dominant, externally driven and consumption strategies are most dominant in Zimbabwe. There are high percentages of farmers who eat food that is not normally eaten in Lower Gweru and Lupane (see Figure 36). For instance, in Lupane they make porridge from rosewood (*mchivi*) and *mviyo*, wild plants. They get food relief from Christian care and Catholic Relief Services (CRS). It would be ideal to engage mostly in income strategies as they may enable farmers to address food shortages and at the same time deal with additional challenges brought about by climate variability such as financing veterinary needs and buying other required household provisions. Increasing evidence across the region indicates that rural households are engaged in a mix of strategies for either raising or supplementing income (Drimie and Gandure, 2005 and Thomas *et al.*, 2006).

In this section, responses to changes in food availability have been categorised into labour based strategies, consumption strategies, income strategies and externally driven strategies (Figure 35). This is based on the different ways in which strategies have been categorised in the literature (Drimie & Gandure, 2005 and Phillips, 2006). In this thesis, labour based strategies include provision of labour to the household and soliciting for labour to replace that which has been lost to the household. Such strategies include migration, taking children out of school and off farm work. Changes in consumption patterns are aimed at improving food security and involve the reduction in the number of meals eaten, skipping of the number of meals taken per day, consumption of seed stocks, eating food that is not normally eaten and begging for food from the extended family and other sources. Moreover, income strategies are aimed at increasing income for the household. These strategies include the sale of assets including livestock and household assets and borrowing cash.

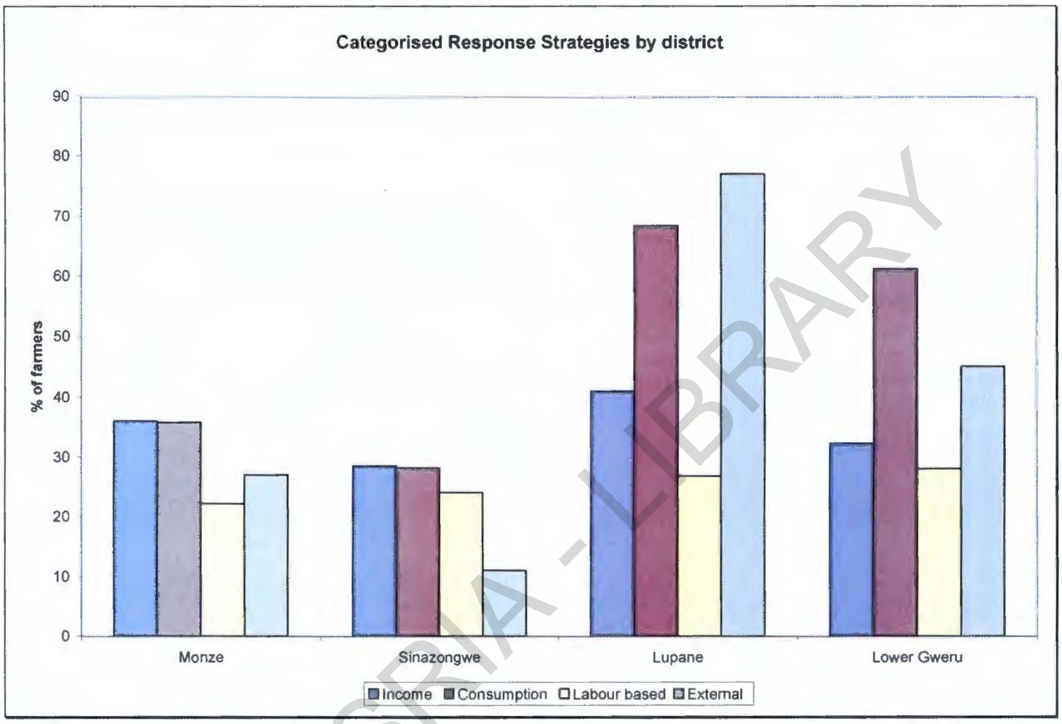

Figure 38: Responses to changes in food availability by district

5.4.2 COPING VERSUS ADAPTATION

This section establishes whether the strategies used by farmers are either coping or adaptation strategies, based on available literature. Coping strategies are defined as actions that are invoked following a decline in "normal" sources of food, and which are regarded as involuntary responses to disaster or unanticipated failure in major sources of survival (Ellis, 1998). They are considered to have evolved over time through peoples' long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the season as it unfolds (Cooper *et al.,* 2007 and Mortimer & Manvel, 2006). Adaptation strategies are defined as "means of permanent change in the ways in which food is acquired, irrespective of the year in question" (Davies 1993: 60). These strategies are also positive actions to change the frequency and/or intensity of impacts, as opposed to coping strategies that are responses to impacts once they occur (Adger *et al.*, 2003; IPCC, 2001 and Reid & Vogel, 2006). Given this background, this thesis analyses whether each strategy is used in times of stress, in good seasons or all the time in order to establish whether it is a coping or adaptation strategy. In this thesis, those strategies which farmers use more in times of crises than all the time are considered to be coping strategies, which deal with the immediate crisis. On the other hand, strategies which farmers use both in good and bad seasons are considered to be adaptation strategies as they are adjustments that farmers make to deal with crises and also to maintain stabilisation in household food security.

5.4.2.1 Adaptation strategies

Potholing[18], in this instance, can be categorised as an adaptation strategy for all districts as above 50% of the farmers indicated that they use it all the time that is, whether it is a good or bad season (see Figure 39). The same can be said for ripping in both districts in Zambia and in Lupane. Use of crop residues is an adaptation strategy more for Sinazongwe, Lupane and Monze, but could be classified as both coping and adaptation for Lower Gweru. While winter ploughing is considered to be an adaptation strategy for all districts, conservation basin making is also a form of adaptation for all districts except Lower Gweru where it can be considered to be a form of both coping and adaptation.

The same applies for crop rotation. Essentially, what is emerging is that use of conservation farming methods is generally an adaptation strategy for farmers in all districts except in Lower Gweru where it is largely used as a coping strategy. Rather than using this strategy immediately there is a bad season, farmers have learnt to use the strategy and have made adjustments by using it regardless of whether the season is good or bad in order to enhance yields. This demonstrates that farmers are making small adjustments to their farming practices in response to their understanding of changes in certain climate parameters. In a study done in South African districts of Mantsie, Khomele and EMcisteni, it was found that use of similar strategies was adaptation as farmers were making adjustments to their farming systems after noticing changes in climate (Thomas *et al.,* 2007). This points to the importance of agricultural extension in engaging farmers in order to maximise yield. In this regard, the weakening of government capacity already highlighted threatens the sustainability of this adaptation strategy.

The buying of food by farmers can be considered to be a form of adaptation in Monze and Lupane (see Figures 40 and 41 for reference to this section). It appears that farmers in these districts had resorted to buying food not only during droughts or floods, but also in years that they considered to be good as they anticipated that bad seasons would follow and they would

[18] Pot holing refers to a conservation farming technique that involves making holes in the field. During crop production, inputs such as fertilizers/manure, seed, water and lime are all concentrated in the prepared hole as opposed to being spread over an area in furrow cultivation (USAID, 2000).

still need grain to feed their families. This is not surprising as there are also indications that the same districts are more engaged in income strategies in their respective countries than the other sampled districts, hence the assumption that they would have more disposable income than farmers in other district. Clearly, off farm work has become an adaptation strategy for farmers in Zimbabwe and Sinazongwe district. Off farm work is an adaptation strategy that is used by all districts all the time except for Monze. Farmers indicated that off farm work involves petty trading, casual labour, handicraft, beer brewing and selling firewood, among others. This strategy has been well integrated in their seasonal calendar as livelihood activity, regardless of whether the season is good or bad. This is understandable for these districts considering their agro-ecological zones and the 'double exposure' for Zimbabwe districts.

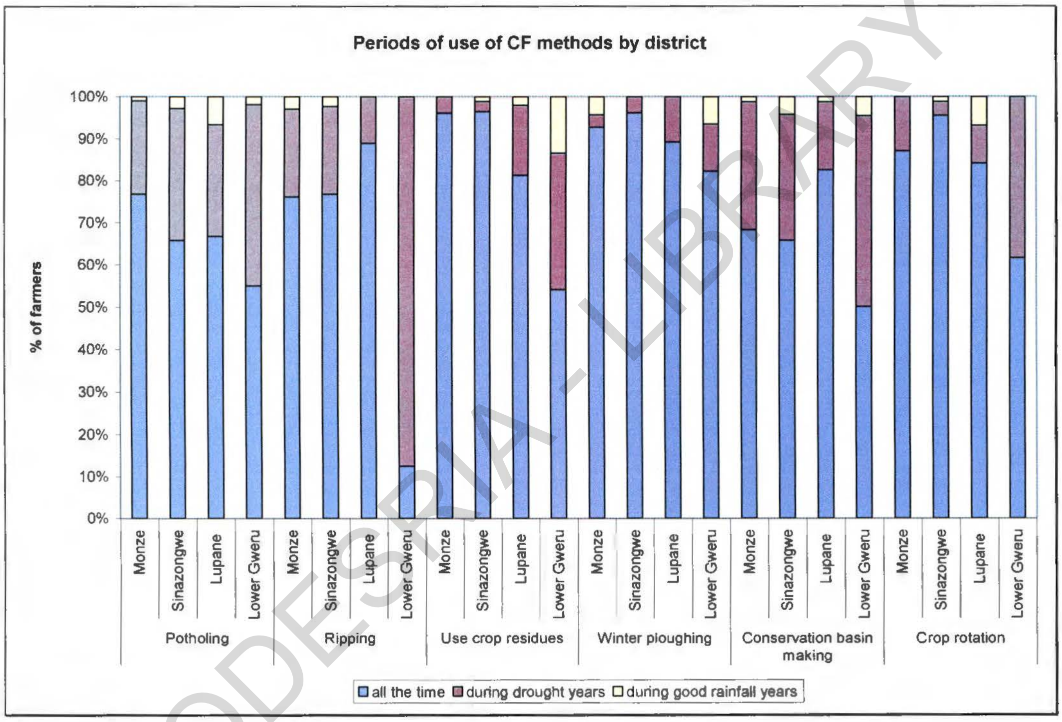

Figure 39: Periods of use of conservation farming methods by district

By implication, the importance of off farm work diminishes as food security and income increase. In a study done in Central Tanzania, it was found that there was a shift from perceiving non-farm activities as merely coping strategies to an incorporation of these activities into mainstream livelihood activities (Liwenga, 2003). What is also emerging is that adaptation strategies do not necessarily improve the plight of farmers given that off farm work may lead them into cycles of poverty as they leave their farms with inadequate labour to source for income.

Migration from area by household members to seek for jobs and then send money back home (remittances) has become an adaptation strategy in all four districts. Farmers in both countries concurred that although remittances is not a very dominant strategy, farmers have for some time now benefited from their children and relatives who send them money and other household provisions as the seasons have become more and more unpredictable. For farmers in Zambia, sale of assets is a way of adaptation. They indicate that they sell livestock regardless of season because livestock rearing is part of their economies. This is not surprising because the Southern province is generally renowned for livestock rearing. Buyers therefore frequently visit these districts in search of livestock. While the selling of assets has been considered to be a high risk and low return coping strategy that only works for households in the immediate term but still leave them worse off than before (Phillips, 2007), it appears that access to assets and resources increases household capacity to adapt and would be expected to reduce the likelihood of use of coping strategies. This strategy is however under threat as buyers have started insisting on low pricing and livestock diseases have been on the increase as highlighted under multiple stressors.

The hiring of labour has been used as an adaptation strategy in Lower Gweru and Monze. In Monze, one farmer even indicated that in a good season they would even consider marrying another wife so that they can increase the labour that the household has. These farmers have learnt that through additional labour in their household, they can enhance their yields regardless of a good or bad season. This could also indicate that since these districts are better off than Sinazongwe and Lupane in terms of food security, they may have the resources to hire labour and they may also be driven by the anticipation of adequate rains, given their geographical locations.

Sinazongwe and Lupane districts have adapted to food shortages by using gardening as a strategy. This suggests that when farmers are faced with continued episodes of food shortages, they tend to make permanent adjustments to their farming systems to deal with these shortages. Gardening has therefore become a permanent way of supplementing the continual low yields which farmers in these semi-arid areas face, unlike in Lower Gweru and Monze where they would intensify gardening in the face of a shock.

5.4.1.4 Strategies in response to changes in food availability

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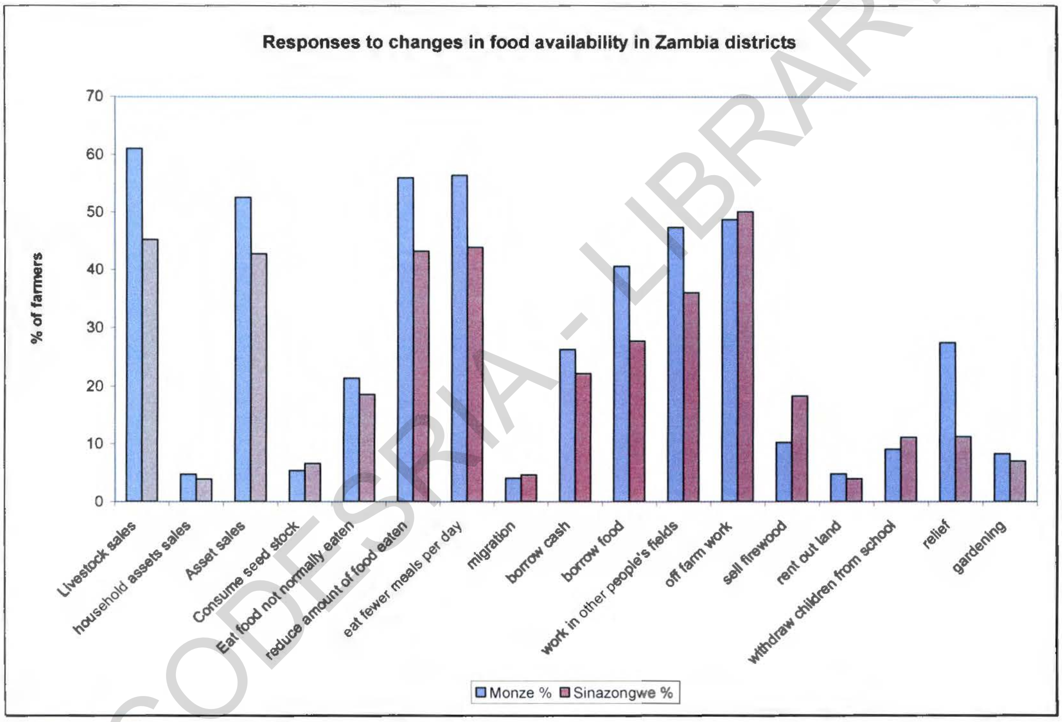

Figure 36: Responses to changes in food availability in Zambia by district

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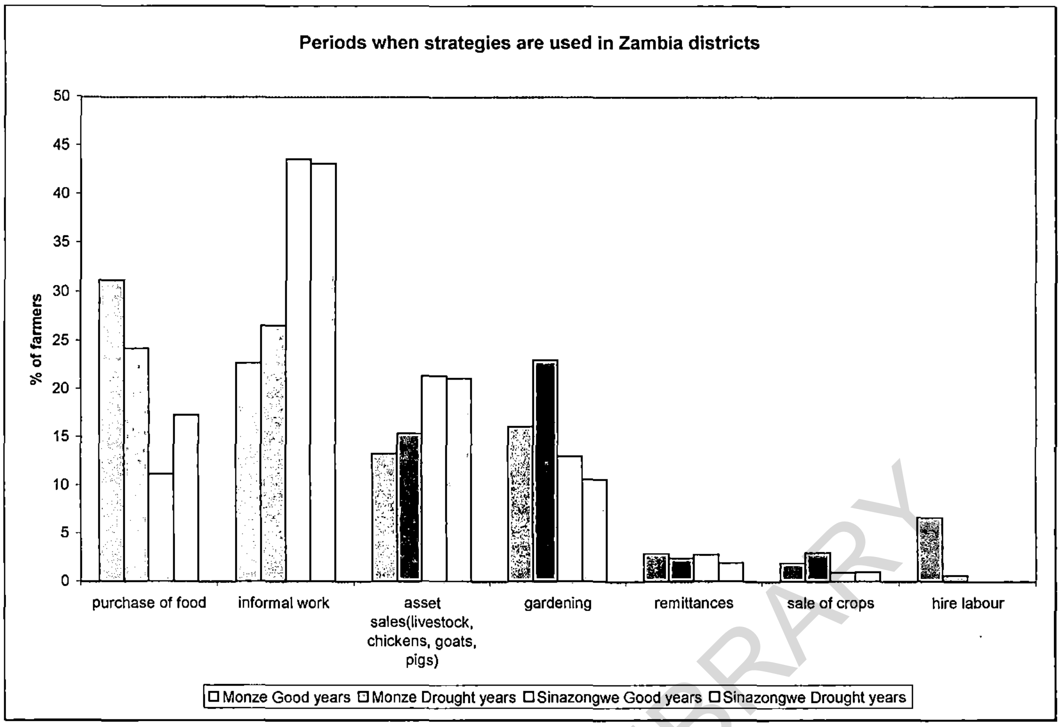

Figure 40: Periods of use of response strategies in Zambia by district

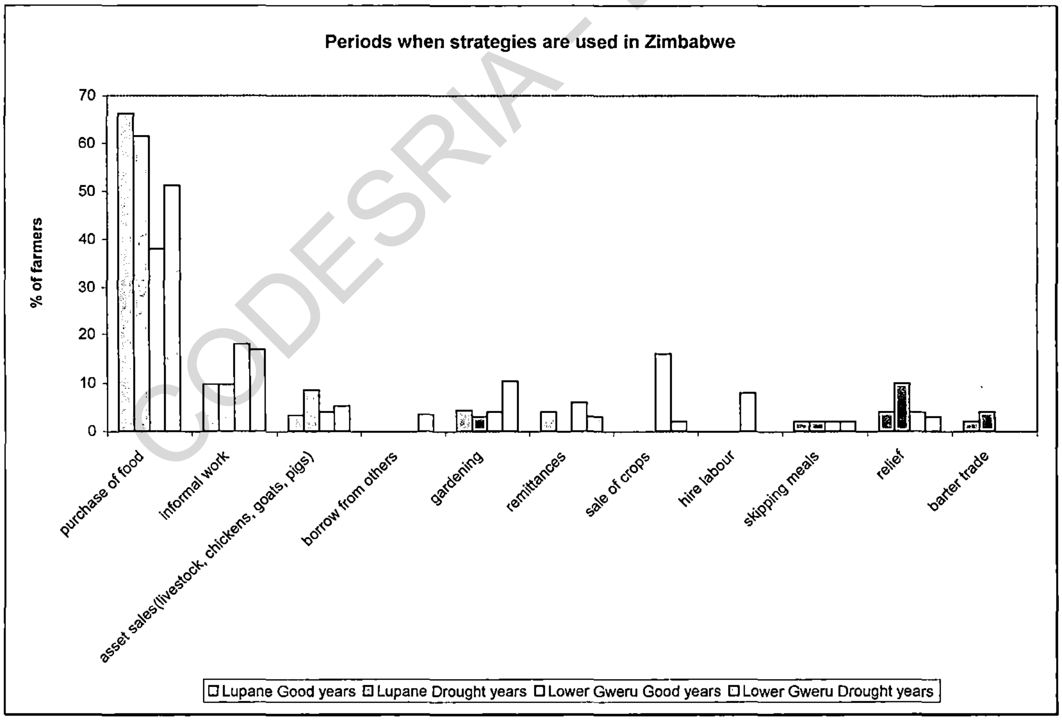

Figure 41: Periods of use of response strategies in Zimbabwe by district

5.4.2.2 Coping strategies

Ripping[19] is mainly employed as a coping strategy for Lower Gweru as it is mainly used by 90% of the farmers during droughts. When the season is good, they do not engage in ripping, unlike in all the other districts where this has become a part of their farming systems. The same is true for conservation basin making and use of crop residues. It has been highlighted that this district is one of the districts in Zimbabwe with a history of food security, which could be why these farmers do not see the need to adjust their farming systems by engaging in conservation farming unless they are faced with a crisis. While in Monze they have also been involved in off farm work over time, this is a coping strategy for them as they immediately turn to off farm work when they have lost their crops in a bad season. They intensify their engagement in this strategy in a bad season more than they would in a good season, in which case they would not need to do much of off farm work considering that they will have acquired adequate food for their households and also, logically, because they would not want to lessen the available labour for the household. Although coping is considered to handle short-term crises to managing chronic, seasonal food stress, it may also be considered as an incorporated and intrinsic part of rural livelihood systems which are always present to some degree and which are drawn upon when needed (Thomas *et al.,* 2007). Moreover, because non-farm activities have been understood as additional sources of income for farmers (Liwenga, 2003), it would explain that Monze farmers, who are in a wetter area than Sinazongwe and with less multiple stressors than Zimbabwe districts, would not need these unless they had been hit by a shock.

Gardening and sale of crops are other coping strategies that Monze farmers engage in. Over the years, these farmers have got lower and lower yields, a fact that has meant that they have had to restrict the selling of crops. However, when they are faced with a crisis, they tend to sell the little that they have to earn the much needed income at this time. The same is true for Lower Gweru in gardening. Although farmers indicated that they engage in gardening most of the time, they find that when their crops have failed due to a bad season they intensify gardening and increase the land under cultivation in their gardens as a rapid response to the crisis. For Zimbabwe farmers, asset sales are a coping strategy as they normally hold on to their livestock, which is considered to be a sign of wealth. In these districts, having livestock gives greater status to the owner within society. They indicated that when they are faced with food shortages, they find that they have to dispose of their livestock in order to deal with these shortages. The sale of livestock is therefore done as a last resort, which is unlike the situation

[19] Deep cultivation (greater than 20 cm), which may benefit soils with poor structure or compaction problems. Like most forms of cultivation, deep ripping can loosen and 'soften' the soil, giving plants access to deeper soil (USAID, 2000).

in Zambia. In this regard, it is emerging that coping and adaptation strategies vary with local conditions.

Reliance of farmers on external relief and barter trade are some of the coping strategies that Zimbabwe farmers use immediately they are faced with a crisis. It is not surprising that these strategies are unique to Zimbabwe farmers, who have already been documented to be facing additional and complex crises to climate variability. A major concern arises when farmers rely on relief to get food in times of food shortages as there has always been a question of sustainability of interventions that bring in food and aid in other forms. What happens to these farmers when aid dries up? There have been concerns that the effectiveness of these interventions may be questionable and therefore heavily depending on interventions may not be prudent for farmers (Bhadwal, 2006). In Zimbabwe, 61.7% of the interviewed farmers highlighted that they rely on aid to get food to feed their families against only 19.1% in Zambia. Another study done in India (Bhadwal, 2006) also shows how 24% in one site and 42% in another site of the interviewed farmers depend on interventions from government. This shows that the percentage of farmers in Zimbabwe who depend on interventions is much higher than in other countries where similar research has been done.

An interesting finding that has emerged is that coping and adaptation are contextual. What might be considered to be a coping strategy in one district may be an adaptation strategy in another district.

5.4.2.3 Coping with and adapting to climate variability and change among farmers in the study areas

While section 5.4.2.1 has outlined the general response strategies by farmers in climate variability, section 5.4.2.2 has highlighted how these strategies are employed either as a way of coping or adapting to this variability. This section illustrates farmers' concrete experiences in responding to climate variability by presenting case studies from Lupane and Monze districts.

- *The case of Jophina Sabe*

Jophina Sabe from Lupane district is chronically ill and was born in 1957. She has been widowed since 1998, after being married for 18 years. After her husband's death, Jophina's husband's relatives took away all her property. She had to relocate back to her parents' home. Jophina has three children, two of whom are doing menial jobs in the city and one is living with her. A number of factors have led to her problems as in addition to not having livestock for draught power and the problems in the country, she feels that the erraticity of the rains has really affected her household. Of late, it has been difficult, if not impossible, to get agricultural inputs on the formal market and when they do get them it is late in the season, around December, and the prices are prohibitive. Back in the 1980s, Jophina indicates that she would get maize yields as high as 104 x 90kg bags. However, those times have passed and in 2004/5 she got 5 x 50kg bags and in 2007/8 she had no bags due to excessive rains. Her fields were washed away and she lost all her crop. Jophina highlighted that when yields started going down with bad seasons from around 2001/2; she decided to engage in petty trade and has a market stall. *'When I realised that my family was about to starve due to crop failure, I decided to go to Gweru (around 2004) and partner with a friend. We hired a market stall to sell our commodities from. However, this business did not last long as we became broke after we were heavily affected by escalating inflation around 2006 going to 2007. we no longer got much from the business in terms of profits, which is why I abandoned the business and returned to the village but by then my son was already in Form 3, after which he continued with night school.'* Jophina has a small garden which does not yield much except for subsistence. She had therefore resorted to buying produce from other farmers' gardens and selling it to get profit. She would sell the produce to gold panners, but when her sales were again eroded by inflation she stopped this trading. This was her major livelihood strategy, thus she has been affected heavily as her income has declined. As a result, she now relies on receiving aid from CARE. She receives a 20 kg bucket of maize, one litre of cooking oil and beans. This allocation usually lasts for three weeks, after which she eats vegetables only until she gets the next allocation. Jophina, at the beginning of each season, puts compost in her maize crop. She picks manure from gardens and pastures and also collects leaf litter to make compost for her crop. Of late she has started growing maize alone as she cannot get seed to diversify, since 1998. While she owns only one hectare of land, Jophina does not recall a season where she cultivated the whole piece of land. In 2007/8, she even cultivated 0.404 ha as this was the only area on which she had done winter ploughing. After the first stage of winter ploughing, there were excessive rains which did not allow her to increase the area under cultivation. She recalled that prior to 2000, she would do winter ploughing on the whole piece of land.

- *The case of Maria Mweemba*

Maria Mweemba was born in 1937 and is the first of five wives in a polygamous marriage to the headman of Sikaula village in Monze. Between them, they have 35 children but almost all of them have left either to stay in cities or to have their own homesteads in the same village once they have married. Maria indicated that her family has in the past been affected by droughts and recently, floods. She gave an example of the most recent dry years that she could recall as 2005/6 and 2006/7. Thereafter, the next season that followed (2007/8) was characterised by floods. In these dry years, she recalled that their crops dried up and their maize crop was affected by pests from the root and others from the heart. Their wells in their home and gardens also dried up during these periods. In the flood season, there was water logging in their fields and even had water reaching knee height in the fields. In addition, there were so many malaria cases at her home with their grandchildren mainly being the worst affected. While as a homestead they would get an average of 520 x 50 kg bags of maize yield under normal circumstances, in this period they got only 50 x 50 kg bags of maize as the overall yield. For the family, all the wives work in the fields collectively and have one storage place and share the yield. Maria indicated that before these crises, her family never had to join cooperatives for loan schemes as they were always self-sustaining and could afford to purchase agricultural inputs for the following season. They even over the years managed to acquire sound agricultural implements that include tractors, harrows, cultivators and ploughs, among others (see Photos 5 and 6). Although she failed to state the exact number of livestock that the household has, she indicated that there are plenty which belong to the husband and separate ones for each wife, herself having seven cattle and nine goats. In recent years, the case is different as they will have got low yields in the previous season, with food not being enough, they would therefore have to buy more in order to feed the large family. In the previous season, they joined a cooperative for acquiring inputs and even then, what they acquired was not enough. To deal with these food shortages, Maria's family has had to resort to buying food over the years since the droughts started. Also in drought periods, the wives intensify their gardening in addition to crop cultivation from which they expect to yield less when the season is bad. Essentially, the major source of livelihood for the family is crop cultivation but they intensify gardening activities when they get low yields. Moreover, remittances from their children have gone a long way in cushioning them in the years that they have not had good yields. They also decreased the area under cultivation in this season although she could not talk in terms of the exact hectarage.

Photo 5: Agricultural implements owned by Maria's household

Photo 6: Tractor owned by Maria's household

These case studies reinforce what has been alluded to earlier on in this section; that the hiring of labour and having a large family is seen to be very important and as a way of adapting to food shortages in the household, a belief which is relatively common in Monze and Sinazongwe (see Table 11). The family in Zambia had over the years managed to remain self sufficient with the availability of labour. In addition, the availability of draught power in the household is critical in enhancing yields as reflected in the case studies cited. The case of Jophina also emphasises the fact that livelihood diversification from agricultural activities has been a critical strategy that is employed by farmers to supplement livelihood.

5.4.3 Factors influencing choice of coping and adaptation strategies

Having focused on adaptation by farmers in the study areas, it is important to understand what factors influence their adaptation to climate variability and change by country. The complex factors that determine the success of these strategies have been identified as including access to resources, household size and composition, access to resources of extended families and the ability of the community to provide support, among others (De Waal, 2005 and Mutangadura, Mukurazita & Jackson, 1999). Based on existing literature, five groups of factors were tested (see Table 20), which are, (i) demographic factors, (ii) access to information and technologies, (iii) assets and resources, (iv) membership of groups is used as a proxy for access to informal institutions and (v) vulnerability; whereby it is hypothesised that farmers in Zimbabwe are more vulnerable due to the economic climate in that country. A logistic regression is then used to analyze factors that influence the use of different coping and adaptation strategies. Therefore, the model is measuring factors that affect use of various coping and adaptation strategies.

The dependent variables, which is Y, is either an adaptation or coping strategy presented in Table 21 or the conservation farming methods presented in Table 22. The general model is;

$$Y=b0 + bX1 + bX2+\dots\dots\dots +bXn$$

Y=either 0 or 1 where 0 means no use of strategy and 1 represents use of strategy.

Selected strategies from adoption of conservation methods and other strategies and how they are influenced by different factors are presented in Tables 21 and 22. The most dominant strategies in the two countries are selected for the model.

Age of household heads can influence the livelihood strategies pursued by the households. According to Ellis *et al.* (1998) and Bebbington (1999) family life cycle characteristics such as age, education, and the number of family members can influence household's and individual's objectives, such as risk management practices, consumer preferences, and/or strategies available to cope with shocks. In the model in Table 22, there is a positive and significant correlation between age of household heads and use of potholing. Similarly, in studies done in Ethiopia and Kenya, older household heads were more likely to adopt climate change adaptation measures in the form of conservation farming technologies than were younger ones (Yesuf *et al.* 2008; Anjichi 2007). In addition, Table 21 shows that younger households are more likely to eat food that they normally would not eat during times of food shortage as well as resort to gardening. Older households, on the other hand, are more likely to reduce the amount of food they eat when faced with food shortages resulting from climate change and climate variability.

Table 20: Definition of variables influencing adaptation

Demographic	
X1- Age of household head	Age of household head in years
X2- Sex of household head	Sex of household head 0=Male, 1=Female
X3 -Marital status	Marital status of household head 0=Unmarried, 1=Married
Access to information and technologies	
X4- Access to weather information	Whether household is accessing weather information 0=No, 1=Yes
X5 -Participation in training	Whether any member of the household has participated in any agricultural or climate related in training 0=No, 1=Yes
X6 -Education level of household head	Education level of household head 0=No formal education, 1= Have primary, secondary or tertiary education
X7 –Perception of climate variability	Observations of any weather changes by household in the past years 0=No, 1=Yes
Assets and Resources	
X8 -Land owned in previous season	Size of land owned by household in previous season in ha
X9 -Cattle numbers	Number of cattle owned by household
X10- Poverty	Household own perception of their level of poverty 0=Poor, 1= Medium or Rich
Institutions	
X11- Membership of group	Whether any member of the household belongs to a farmer group/association 0=No, 1=Yes
Vulnerability	
X12- Harvest duration in good year	Duration of harvest of main cereal in a good season in months
X13- Harvest duration in bad year	Duration of harvest of main cereal in a bad season in months
X14 -Country	0=Zimbabwe, 1=Zambia

This could be the case because reports from group discussions revealed that in drought situations, younger men and women migrate to other areas and leave their homes to engage in gold panning and other trading activities such as cross border trade, particularly in Zimbabwe. The same reports indicated that younger farmers have less land at their disposal than older farmers, which could explain why younger farmers engage more in gardening, an activity that requires less space, either close to the homesteads or in the wetlands.

Results (Table 21) further show that female headed households are more likely to borrow food and cash than male headed households. This is consistent with the hypothesis that female headed households are more likely to engage in erosive strategies than male headed households. This coping strategy is considered to be a 'dangerous' one as the households concerned will have to return the food or cash soon after harvests, leaving them more vulnerable as they have less food or cash to last them the season and to be prepared if disaster strikes (Young & Jaspars, 1995). This may leave households in a cycle of poverty from one season to the next. Literature shows that this finding has to do with unequal access to resources by females in most African countries. Females have been found to have less access to resources such as land, property and public services (Agarwal, 1991; Nemarundwe, 2003; Njuki *et al.,* 2008 and Thomas-Slayter *et al.*, 1995).

It is therefore an unexpected result in the analysis that there is a positive and significant relationship between sex and adaptation strategies such as potholing, winter ploughing and changing crops (Table 22). This implies that households that are headed by females are more likely to engage in these adaptation strategies than those headed by males. This is inconsistent with other studies that have highlighted that households headed by males are more likely to adopt technologies such as putting up soil erosion structures, fallowing and use of fertilizer and manure in Kenya, Cote D'Ivore and Burkina Faso (Adesina, 1996; Matlon, 1994 and Njuki *et al.,* 2008). Be that as it may, this study also finds that females (41%) are significantly more engaged in group activities than males (35%).

It would therefore appear that group membership influences farmers' adaptation, implying that this domination of farmers' groups by females may lead to subsequent adaptation by female (49%) who are also significantly involved in formal and informal training activities. What is emerging here is that social networks and relations may offset the vulnerability of farmers. Group membership is considered to be one of the elements of social capital (Njuki *et al.,* 2008). There was a similar assumption therefore that members of farming groups and associations should be in a position to employ adaptation strategies if they can adopt technologies (Dube *et al.,* 2007). Consistent therefore, is the result that there is a positive and significant relationship between group membership and winter ploughing. It may therefore be worrying that the social fabric, which is important, has been found to be deteriorating due to economic realities.

Indicators of access to information and technologies as expected to influence the use of different strategies. Households that had heads of households with primary, secondary or tertiary education were more likely to engage in off-farm work as were those who had training in agriculture. Higher education of course increases the likelihood of people having opportunities for off farm employment and such households are therefore more pre-disposed to using income from these sources to cope with food unavailability. Similarly, it is not surprising that farmers with access to climate information were less likely to use erosive strategies such as borrowing food or cash or eating food that is normally not eaten including eating seed. Srivastava and Jaffe (1992) argue that access to weather information is critical for the planning of farmers' agricultural activities and enhancement of their adaptive capacity.

Table 21: Factors influencing responses to climate variability and its outcomes

Variable	Asset sales	Food not normally eaten	Reduced food quantities	Borrow food/cash	Off farm work	Gardening
Demographic						
Age of household head	0.004 (0.006)	-0.013** (0.006)	0.014** (0.007)	0.011 (0.011)	-0.003 (0.006)	-0.013* (0.007)
Sex of household head	-0.293 (0.228)	0.032 (0.261)	-0.307 (0.280)	1.224*** (0.387)	0.099 (0.232)	0.121 (0.295)
Marital status	-0.204 (0.215)	-0.170 (0.248)	-0.182 (0.255)	-0.399 (0.368)	-0.085 (0.220)	0.333 (0.286)
Access to information and technology						
Access to weather information	0.081 (0.188)	-0.645*** (0.205)	-0.013 (0.245)	-0.781** (0.368)	-0.080 (0.193)	-0.150 (0.227)
Participation in training	0.047 (0.178)	0.211 (0.206)	0.204 (0.223)	0.437 (0.347)	0.307* (0.183)	0.111 (0.224)
Education of household head	-0.050 (0.236)	-0.313 (0.267)	0.288 (0.297)	0.632 (0.480)	0.422* (0.241)	0.006 (0.292)
Perception of climate variability	0.010 (0.241)	-0.124 (0.275)	-0.566* (0.330)	-0.148 (0.480)	-0.292 (0.249)	0.389 (0.289)
Assets and resources						
Land owned in previous season	-0.082** (0.041)	-0.019 (0.050)	-0.039 (0.044)	-0.105 (0.078)	-0.036 (0.041)	0.051 (0.057)
Land cultivated in previous season	0.129** (0.052)	0.126** (0.063)	-0.060 (0.065)	0.070 (0.116)	-0.060 (0.053)	-0.177*** (0.067)
Cattle numbers	0.020 (0.018)	-0.031 (0.020)	-0.027 (0.021)	-0.075* (0.044)	-0.090*** (0.022)	0.040* (0.022)
Poverty	0.602*** (0.181)	-0.092 (0.210)	0.057 (0.229)	0.573 (0.361)	-0.250 (0.186)	0.048 (0.229)
Institutions						
Membership of group	0.096 (0.179)	0.147 (0.206)	0.232 (0.227)	0.653* (0.346)	-0.215 (0.183)	0.272 (0.219)
Vulnerability						
Harvest duration in bad year	-0.024 (0.033)	-0.162*** (0.040)	-0.127*** (0.038)	-0.065 (0.058)	-0.079** (0.034)	0.003 (0.044)
Country	0.153 (0.205)	-1.721*** (0.229)	-2.238*** (0.270)	20.859 (0.734)	0.036 (0.210)	-2.892*** (0.288)
Constant	-0.614 (0.512)	2.231*** (0.595)	2.626*** (0.639)	-22.834 (0.734)	0.958* (0.529)	0.409 (0.652)

*, **, *** significant at the 10%, 5%, 1% levels

Table 22: Factors influencing use of conservation farming methods in climate variability and its outcomes

Variable	Potholing	Use of crop residues	Wint. PL	Con. Bas. making	Growing D.T crops	Changing crops
Demographic						
Age of household head	0.015**	-0.007	0.005	-0.002	-0.016	-0.008
	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.006)
Sex of household head	0.455*	-0.231	0.447*	0.148	-0.109	0.593**
	(0.254)	(0.259)	(0.249)	(0.246)	(0.242)	(0.253)
Marital status	0.234	-0.081	0.530**	-0.013	-0.161	0.209
	(0.240)	(0.242)	(0.240)	(0.228)	(0.229)	(0.233)
Farming experience of household head	-0.002	0.001	-0.004	0.007	0.008	0.001
	(0.003)	(0.002)	(0.008)	(0.009)	(0.008)	(0.002)
Access to information and technology						
Access to weather information	0.050	-0.020	0.124	-0.018	0.357*	0.064
	(0.075)	(0.066)	(0.205)	(0.039)	(0.202)	(0.083)
Participation in training	0.350*	0.598***	0.271	0.946***	0.295	0.327*
	(0.208)	(0.201)	(0.199)	(0.199)	(0.194)	(0.195)
Education level of household head	0.032	-0.806***	0.165	-0.313	0.117	-0.162
	(0.280)	(0.274)	(0.272)	(0.258)	(0.254)	(0.268)
Perception n of climate variability	0.247	0.900***	0.184	-0.135	0.251	0.960***
	(0.296)	(0.297)	(0.272)	(0.261)	(0.257)	(0.296)
Assets and resources						
Land owned in previous season	0.086*	0.008	0.089**	0.050	0.033	0.098**
	(0.045)	(0.046)	(0.043)	(0.044)	(0.046)	(0.049)
Land cultivated in previous season	-0.210***	-0.025	-0.123**	-0.043	-0.018	-0.026
	(0.074)	(0.064)	(0.060)	(0.060)	(0.059)	(0.064)
Cattle numbers	-0.057**	0.018	0.024	-0.002	0.044**	0.013
	(0.025)	(0.019)	(0.018)	(0.019)	(0.022)	(0.019)
Poverty	-0.147	0.551***	0.283	0.137	0.349*	0.404**
	(0.210)	(0.207)	(0.197)	(0.198)	(0.198)	(0.200)
Institutions						
Membership of group	0.033	-0.493**	0.569***	-0.483**	0.034	0.160
	(0.208)	(0.204)	(0.190)	(0.197)	(0.197)	(0.199)
Vulnerability						
Harvest duration in good year	0.026	-0.065**	-0.007	0.001	-0.027	-0.029
	(0.028)	(0.027)	(0.025)	(0.026)	(0.026)	(0.026)
Harvest duration in bad year	0.100**	0.127***	0.051	0.006	0.101**	0.092**
	(0.044)	(0.044)	(0.041)	(0.042)	(0.045)	(0.042)
Country	0.781***	1.275***	-0.746***	0.581***	-0.543**	1.105***
	(0.233)	(0.218)	(0.227)	(0.216)	(0.228)	(0.217)
Constant	-2.924***	-0.863	-1.983***	-1.056*	0.504	-2.243***
	(0.635)	(0.594)	(0.586)	(0.569)	(0.566)	(0.595)

*, **, *** significant at the 10%, 5%, 1% levels

Therefore, the negative relationship between education and use of crop residues may be puzzling at face value. By implication, farmers who are educated are less likely to use crop residues. This is unexpected because the level of education of household heads has been documented to be an important determinant of adoption of technologies and an educated farmer can readily access relevant information (Anjichi *et al.,* 2007; Asfaw *et al.,* 2004; Jayne *et al.,* 2004; Mapila *et al.,* 2002; Nkamleu, 2007 and Yesuf *et al.,* 2008). However, it is important to understand that traditionally, residues are used to feed livestock and with no information on potential benefits of retaining residues, farmers are likely to continue prioritizing livestock feeding. Understandably, reports from focus group discussions show that pastures have been affected by the recurrent droughts, possibly explaining why farmers may not be too keen to use crop residue in their fields.

Similarly, participation in training sessions by farmers has a positive and significant influence on their choice of adaptation strategies such as potholing, crop residue use and changing crops. This is consistent with literature that underscores the role played by formal and informal institutions in addressing the issue of climate change adaptation by farmers (Yesuf *et al.,* 2008). Similarly, survey results indicate that most of the organised training that has taken place in Zambia and Zimbabwe has been largely on conservation farming technologies (40%) and crop management (21%). In addition, participants in focus group discussions reported that government extension agents (AGRITEX in Zimbabwe and MACO in Zambia) assist them with extension services that address climate change adaptation in conjunction with seed houses that breed seed varieties suitable for varying areas and climates. A study by Deressa *et al.* (2008) in the Nile Basin similarly posits that access to formal agricultural extension, farmer to farmer extension and access to weather information guarantees that farmers apply adaptation measures on their farm in comparison to those that do not have this access. Similarly, access to weather information is positively related to the growing of drought tolerant crops and varieties. This is understandable as farmers would grow drought tolerant crops when they have been alerted of a drought or inconsistent rains. It is therefore a disturbing fact that government services have been found to be on the decline given the critical role that they play in enhancing adaptation.

There is a positive and significant relationship between the size of land cultivated by a household and eating food not normally eaten. This suggests that the more land farmers cultivate, the more they eat food they do not normally eat. Where farmers with larger pieces of land are expected to adopt technologies more (Njuki *et al.,* 2008) and by implication cope less, it has been documented in a study done in Zambia and other Southern African countries such as Malawi and Mozambique that farmers cultivating more land are likely to use less amounts of fertilizer across the large area vis intensifying and targeting use within a small area (Njuki & Mapila, 2007). By implication, productivity may be low in larger pieces of land, explaining why farmers who cultivate smaller pieces of land are less likely to engage in erosive strategies. Moreover, the negative relationship between land cultivated and gardening implies that farmers cultivating less land are more engaged in gardening, possibly to supplement food stocks.

There is a negative and significant relationship between land cultivated in the previous season and potholing and winter ploughing. The suggestion herein is that as farmers increase land under cultivation, they are less likely to adapt by engaging in winter ploughing and potholing. Engaging in potholing and winter ploughing entails extra labour for farmers as they have to increase the number of times that they plough. Therefore, having more land under cultivation would require draught power and extra effort from farmers. Moreover, report from group discussions highlighted that farmers have reduced land under cultivation for other various reasons that include high input price, climate variability and inadequate access to draught power, among others. A similar trend reported by C-SAFE (Consortium for Southern Africa's Food Emergency) showed that more than 40% of Zimbabwean rural households in 2003 were not cultivating as much land as they previously had (Senefeld & Polsky, 2005).

Land owned has a positive and significant influence on use of potholing and changing crops as adaptation strategies. This result suggests that the size of the farm influences adoption of technologies as the larger the land, the higher the chances and space for engaging in changing crops and potholing. Farmers with larger pieces of land are more likely to experiment and to have a broader crop mix (Njuki *et al.,* 2008).

The period harvests from the previous season lasts is a determinant of whether farmers adapt to climate variability or not. Results from the model show that harvests in drought years positively and significantly influence the employment of strategies such as changing crops, growing drought tolerant crops, use of crop residues and potholing. This suggests that when there has been a bad cropping season, farmers whose harvest lasts longer engage more in adaptation strategies than those whose harvest lasts for shorter periods of time. It is generally assumed that farmers who are somewhat food secure tend to be more resource endowed, older and more labour secure than those who are less food secure, explaining the relationship between food availability and adaptation.

Results show that while there is a negative and significant influence of cattle numbers on potholing, cattle numbers positively and significantly influence the growing of drought tolerant crops. This suggests that as cattle numbers increase, farmers are less likely to engage in potholing. Essentially, this underscores the importance of draught power for smallholder farmers to adapt to climate variability. Indeed, farmers reported that they recognize the significance of cattle ownership as a sign of wealth, particularly in that they get draught power from them.

It is further interesting to note that the location of farmers, that is, which country they are resident in, determines whether they will employ adaptation measures or not. There is a positive and significant relationship between country and adoption of conservation methods such as potholing, use of crop residues, conservation basin making and changing crops. This result suggests that farmers in Zambia are more inclined towards adaptation than those in Zimbabwe. Indeed, this finding is consistent with the finding in section 5.4.1 that adoption of conservation farming is more of a coping than adaptation strategy in Lower Gweru.

5.5 CONCLUSION

The analysis in this chapter suggests that farmers in the two countries are generally aware of climate variability. Specifically, there has been a reduction in precipitation and an increase in temperatures that they have noticed in the past two decades. The climate change and variability effects that these farmers have been confronted with the most are droughts and floods in Zambia and droughts and excessive rains in Zimbabwe. While droughts and dry spells have been witnessed quite often over the years, and even more often in the past decade, floods and excessive rains are a recent phenomenon. Farmers' perceptions of climate change have been found to be congruent with literature on evidence of climate change and variability in Southern Africa. Weather forecasts and early warning systems have therefore been found to be critical for the reinforcement of farmers' awareness of climate variability, which is considered to be important for adaptation.

Farmers highlighted that while they are confronted by a myriad of stressors that include inadequate draught power, livestock pests and diseases, weakening government capacity and HIV and AIDS, among others, climate variability and change remain the most threatening for them. In this regard, although there is a convergence in the problems faced by both countries, Zimbabwe farmers' challenges are more deep rooted as they include economic and political problems in the country. Impacts found have been on sectors such as health, water, agriculture and on the socio-economic context.

In addition, farmers have been found to respond to droughts and floods when they occur. In droughts, they mostly use conservation farming methods and grow drought tolerant crops and varieties. Gardening is also a strategy that farmers use to supplement changes in food availability. In excessive rains and floods, farmers intensify their gardening, particularly in Zambia as they take advantage of the wetlands that are charged for a long time in this period. Farmers also grow crops on fields that are upland in order to deal with the water logging problem which is a common feature during this period. Adaptation and coping strategies vary by district as they are determined in part by local conditions. For this reason, what might be found to be a coping strategy in one district may be an adaptation strategy in another district.

Adaptation is influenced by factors such as age, education level and access to weather information, training and group membership and location among others. These factors have been found to influence adaptation in different ways in the two countries.

Chapter Six presents the conclusions and recommendations of this study based on the analytical framework and objectives guiding the study.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

There is wide consensus that the global climate is changing and that there continues to be increasing climate variability due to the increasing concentration of greenhouse gases in the atmosphere. These changes have been largely attributed to anthropogenic activities that alter the earth's natural processes (IPCC 2007). Projections show that global warming will continue to accelerate. Despite a growing number of country level case studies on impacts of climate change on farming systems, gaps still exist and knowledge regarding socio-economic impacts of climate change in relation to multiple stressors that small holder farmers face is considered to be uneven and incomplete (Boko *et al.* 2007). While the global debate on climate change has largely focused on mitigation strategies, more recently, adaptation and coping with climate variability and change have become key themes in global climate discussions and policy initiatives (IPCC 2007). However, the critical issue in this debate is centred on the distinction between uses of coping strategies as distinct from adaptation strategies.

Given this background, the aim of this study has been to examine how farmers in selected sites in Zimbabwe and Zambia deal with climate variability and change. In order to understand the effect of climate change on the welfare of farm households and their agricultural systems, the study addressed three specific objectives, as highlighted in section 1.3 in Chapter One. This chapter draws conclusions from the findings of this study and suggests recommendations for future policy in the context of the objectives of this study.

6.2 MAIN CONCLUSIONS OF THE STUDY

This section summarises the main findings highlighted in Chapter Five and also presents the main conclusions that have been drawn from these findings.

❖ ***Conclusion One***

While farmers report changes in local climatic conditions consistent with climate change, there is a problem in assigning contribution of climate change and other factors to observed negative impacts on the agricultural and socio-economic system

There was concurrence among farmers in all sampled districts that there has been a shift in the onset of the rains from October to mid and sometimes late November. In addition, temperatures have risen significantly over the years and winters, which now prolong, have also become warmer than before. Therefore, this study found that farmers have the capability to perceive changes and variability in local climatic conditions. Farmer reported trends in climate variables, which are congruent with what has been observed by meteorologists as cited in literature and supported by climate data analyses presented in Chapter Five.

While farmers generally have been found to have the capability to perceive changes and increased variability in climate, farmers in wetter areas are more likely to notice effects of climate change than those in drier areas. While fewer farmers in Sinazongwe (Zambia) and Lupane (Zimbabwe), both dry and marginal districts, reported that they have noticed changes and increased variability of climate, more farmers from the wetter districts of Monze (Zambia) and Lower Gweru (Zimbabwe) indicated that they have experienced significant changes and variability in climate. Essentially, the effects of climate variability and change are less noticeable in an already dry area, where it may be difficult to see if it got even drier. This limited awareness is likely to heighten the vulnerability of farmers in the drier districts as this could mean that farmers are not prepared when these shocks strike.

In the same respect, this study further found that farmers who have more access to weather information are also more likely to notice changes in different climate parameters than those with limited access to weather forecasts. Monze district farmers, who had a farmers' programme on weather forecasts running on a Radio station three times a week, had the highest percentage of farmers indicating that they noticed climate changes and variability.

As is often reported in studies examining livelihoods, the vulnerability context influences capacity to adapt. This study found that with wider and a complexity of challenges to deal with, small-scale farmers may be less inclined to notice changes in climate parameters if they have a multiplicity of challenges to contend with. Essentially, perceptions of risk are to a certain extent shaped by psychological, social, cultural and institutional processes. While farmers are able to recognize changes in climate and to explain low agricultural performance and low well-being in terms of climate change, when there are political, social and economic problems in a country, farmers may not be able to disentangle contribution of each factor to observed outcomes.

Socio-cultural and spiritual factors dominate farmers' views on why climate is changing, as highlighted in Chapter Five. The fact that farmers link the causes of climate change more to their socio-cultural realms than to human activities may be a cause for concern for farmers' decision making processes in climate change adaptation. This has implications for environmental management issues in that farmers may fail to realize the importance of environmental management activities. In this respect, the dynamics of the differences in perceptions are therefore important to understand as this study found that local conditions determine the extent to which farmers perceive changes and variability in climate.

❖ ***Conclusion Two***

While there are multiple stressors that confront farmers, climate variability and change remain the most critical and exacerbate livelihood insecurity for those farmers with higher levels of vulnerability to these stressors

This study focused on multiple stressors as challenges that farmers are confronted with in addition to climate change. It was important to understand from farmers' perspectives how they view problems emanating from climate change in relation to a multiplicity of other challenges that they face. This also illuminated on the vulnerability context of farmers as highlighted by the SLA which is outlined in Chapter Four. In order to assess social resilience to climate variability or climate change, an understanding of the additional stresses that people encounter is also required. Stressors in all districts are dependant on local conditions and economies. For instance, most of the stressors in the Lupane, Sinazongwe and Monze are related to livestock, which is the basis of their economies.

The study concludes that Lupane and Lower Gweru districts in Zimbabwe have more diverse challenges that farmers are facing as compared to Monze and Sinazongwe districts in Zambia. In addition to the climate change and other common challenges that farmers face in all the four districts, Zimbabwean districts are afflicted with the unavailability of inputs on the market and late supply of the same inputs, lack of maintenance of roads and bridges and hyper-inflation, among others.

This study further demonstrated that weakened government capacity in both countries is one of the challenges that have crippled agricultural growth as a result of a general reduction in provision of the needed basic agricultural and other relevant services Government failure has been worse in Zimbabwe over the past decade, and as a result, farmers in Lupane and Lower Gweru have had to contend with a more drastic reduction in crop yields, livestock populations, agricultural income and food availability more than farmers in Monze and Sinazongwe.

However, while there is a multiplicity of stressors that bedevil smallholder farmers in the study districts in Zimbabwe and Zambia, farmers indicated that climate variability and change in its different forms such as erratic rains, frost, droughts and floods are the most critical.

❖ ***Conclusion Three***

There are variations in manifestations of direct and structural impacts from climate variability and change as a result of differences in types of farming systems and general economic and political contexts

Findings demonstrated that impacts of climate variability and change in all the four districts in Zimbabwe and Zambia are mainly on crop yield, the socio-economic context, human and livestock health and water. However, farmers emphasised those impacts which negatively affect crop yield, livestock well-being and water availability. The socio-economic impacts of climate variability were more of a concern for Lupane and Lower Gweru farmers as opposed to Monze and Sinazongwe farmers. In this regard, farmers from Zimbabwe districts attribute their experiences during extreme events to the current political, social and economic contexts, leading to the conclusion that while farming systems are important for farmers, the political, social and economic context of a country may realign farmers' priorities.

In all the districts in Zimbabwe and Zambia, crop failure due to droughts and floods/excessive rains was reported to be significant problems. Many of the drought and floods/excessive rains impacts highlighted by farmers transcend the climate dimension and are clearly played out within the context of other pressures and disturbances on livelihoods. Essentially, outcomes said to be as a result of climate variability and change may actually have many causes. For instance, low production led to lack of food in terms of self sufficiency within the household and at the national level (country wide), and income. In essence, food insecurity during these periods has far reaching impacts that may leave households in a cycle of poverty. A reduction in crop yields implies a reduction in income, which in turn leads to a reduction in farmers' capacity to send children to school and to meet daily livelihood needs.

The findings of the study showed that there are higher levels of vulnerability in Lupane and Lower Gweru than there is in Monze and Sinazongwe as evidenced by a reduction in crop production in the last five years, which is steeper in the former than in the latter. This reduction in crop yield was reported to have been a consequence of both climate related problems and the socio-economic-political environment. Similarly, livestock production is clearly dependent on the productivity of rangelands, which may be linked to the agro-ecological zone in which a district is located. Therefore, droughts would undoubtedly affect the quality of pastures, more so in drier areas, which would in turn affect the amount of draught power that could be provided by livestock. The intensity of impacts of droughts on water availability varied with the agro-ecological zone in which farmers are located. Farmers in Sinazongwe and Lupane are the ones who indicated that they experienced limited availability of water for domestic use and livestock during droughts.

Extreme events affected food prices in all the four districts as price increases became very rapid and large, and transport was disrupted, especially during floods and excessive rains. However, price increases were short-lived in Monze and Sinazongwe during floods but lingered for a protracted period in Zimbabwe districts where disruption of transport systems during excessive rains only exacerbated the pricing systems, which had already become volatile due to macro-economic conditions. Against this background, this study has highlighted how important general economic development will be in reducing the vulnerability of countries to climate change and to increased frequency and intensity of extreme events. Farmers understand impacts of climate variability in terms of their experiences during periods of extreme events such as floods and droughts. These experiences are social and economic rather than purely measured in rainfall deficits.

❖ ***Conclusion Four***

Apart from its overwhelmingly negative effects, climate variability might also have a positive impact and localised benefits in the context of structural changes in communities–social organization and economic activities-under certain circumstances

This study concludes that while to a larger extent impacts from droughts and floods/excessive rains are negative, there are also a few localised benefits that can be capitalised on to improve the livelihoods of farmers in Lupane and Lower Gweru (Zimbabwe) and Monze and Sinazongwe (Zambia). Impacts of climate variability have prompted farmers in Zimbabwe districts to be innovative, more enterprising and diversify into other activities in order to deal with changes in food availability, which they would not have initiated in normal years when food shortages were limited in some areas and non-existent in others. Livelihood diversification has formed the basis of adaptation as distinct from only coping for these farmers. These strategies have remained instrumental even in years when they have received adequate rains.

Other localised benefits due to climate variability and change have been in higher levels of production and productivity obtained by utilizing moisture and alluvial deposits left behind after floods and excessive rains in the districts in both countries. Pastures and vegetation tend to be of good quality during this time. Moreover, there is adequate water for domestic use and for livestock. Gardening activities are conducted throughout the year in floods/excessive rains periods, a factor which may contribute to lower levels of food insecurity in the following season if there is a drought or other forms of climate variability which may adversely affect crop yields. Full maturity for the maize crop which would have been planted late and fruiting of wild trees in periods of excessive rains have also been noted to be some of the localised benefits of climate variability.

❖ ***Conclusion Five***

Significant responses to climate variability and change involve organizing agriculture and related practices, than switching to off farm initiatives

Although an increase in climate variability incidences has prompted livelihood diversification into non-farming activities, particularly for those farmers who have higher levels of vulnerability, farmers still largely engage in agriculture based strategies despite low productivity. The study has shown that farmers have started using non-farm strategies to deal with impacts from climate change and variability. However, it has been found that agriculture based strategies remain important for these farmers regardless of whether the season is good or bad. Despite crop yield reduction and in some cases near total crop loss due to climate induced droughts and floods, farmers continue to engage in crop cultivation season after season.

Findings indicated that while some non-farm strategies in climate extremes are common to the districts in both Zimbabwe and Zambia, most of these strategies are unique to Lupane and Lower

Gweru. The most common livelihood diversification strategies in Monze and Sinazongwe include renting out land and the selling of firewood. Essentially, livelihood diversification in the Zambian districts involves mostly changes in patterns of income generation and adjustment to consumption patterns. While the same strategies are common in Zimbabwe, externally driven activities such as relief interventions in the form of food aid are an important response to climate variability and changes. Migration, withdrawing children from school and the borrowing of food and cash are some of the ways in which farmers in Zimbabwe districts have diversified their livelihoods.

In essence, farmers in the Zimbabwean district engage more in livelihood diversification than those in Zambia districts, who have been found in this study to be less vulnerable. In this respect, this study may contradict the notion that vulnerable populations have little recourse in the face of food insecurity, although further research is warranted to establish the effectiveness of these strategies. If anything, the study has demonstrated that multiple stressors challenge complacency in farmers and force them to act and safeguard their endangered livelihoods. As outlined in Chapter Five, farmers in Lupane and Lower Gweru have a multiplicity of challenges that they are faced with, as compared to those in Monze and Sinazongwe. The study emphasises that diversification of livelihoods is not unique to climate disturbances, but rather, is embedded in the full range of livelihood changing factors such as the multiple stressors highlighted in Chapter Five. Diversity, therefore, can be a necessity in the face of immediate food insecurity.

However, despite livelihood diversification, adoption of conservation methods by farmers is critical for their adaptation to climate variability as all the districts are involved in conservation farming in one way or another. Findings indicated that adoption of conservation methods is dominant during droughts and is intensified when there are floods and excessive rains when farmers create contours in their fields. This study further demonstrated that wetlands are one of the resources farmers use more in floods and excessive rains and less in droughts as gardening activities are carried out in droughts and intensified during periods of floods and excessive rains. The importance of wetlands in small-scale farming as an adjunct to other livelihood strategies cannot be overemphasised. Early planting of crops is another strategy that farmers in the study areas have resorted to using at the beginning of the season. This has been prompted by the increasing unpredictability of the rains. Livestock rearing and crop diversification are also intensified during these periods. There were cases of farmers in Monze who would grow crops such as cassava after floods in order to supplement their food reserves. Farmers also diversify the seed varieties by growing drought tolerant crops and early maturing varieties. This is the most dominant response in all the four districts. Similarly, upland cultivation has proved to be a common response to floods and excessive rains.

❖ ***Conclusion Six***

While farmers' selection of coping and adaptation strategies to climate variability and change and the associated outcomes may be intrinsic, this selection tends to be overwhelmingly

shaped by diverse factors such as demography, access to information and assets and vulnerability levels

This study sought to understand the factors influencing the strategies that farmers use in response to climate variability and change. These strategies were classified in Chapter Five as either coping or adaptation depending on the period in which they are employed by farmers. This was done based on the notion that farmers' use of adaptation strategies may enable them to realize more sustainable livelihoods than use of coping strategies, which tend to only assist them in the immediate term.

Results showed that in all districts, older and male headed households are more likely to significantly use strategies that were employed as a way of coping as opposed to those that were used as a way of adaptation than younger and female headed households. The latter are more likely to engage in strategies used as a way of adaptation, such as potholing, winter ploughing and changing crops.

Households with more social networks were found to significantly incorporate strategies as a way of adapting to climate variability. These include strategies such as off farm work and soil management technologies. Similarly, farmers who have higher levels of education and access to weather information and participate in training activities tend to adjust their farming systems significantly rather than just cope in the immediate term. Essentially, access to weather information is critical for the planning of farmers' agricultural activities and enhancement of their adaptive capacity. In addition, this study showed that knowledge of various soil management technologies depends on socioeconomic variables and the existence of different dimensions of social capital.

Results show that ownership of assets and access to resources positively influences adaptation. For instance, farmers whose harvest lasts longer and own more cattle were found to use strategies more as a way of adaptation as opposed to just coping in the short-term than those whose harvest lasts for shorter periods of time. This includes strategies such as gardening, which farmers in Lupane, Lower Gweru and Sinazongwe used as a way of adapting in the long-term. However, this study demonstrated that there is need to rethink the common notion in the literature that the more land and resources a farmer has, the more they are likely to adapt than cope with climate variability and change. This study highlighted that the more land the farmer cultivates, the more they are likely to cope than adapt as factors such as availability of labour, draught power and agricultural inputs come into play. Essentially, this underscores the importance of draught power for smallholder farmers to adapt to climate variability. Strengthening capital assets through improvements in relevant public sectors becomes important for government in order to foster climate change adaptation by farmers.

The study also showed that the level of vulnerability of farmers influences whether they will cope with or adapt to climate variability and changes. In this respect, the study demonstrated that the location of farmers determines whether they will cope or adapt as farmers in Zambia districts are more inclined towards adaptation than those in Zimbabwe districts. The latter has been shown in Chapter Five to have higher levels of vulnerability. This section has already highlighted that farmers whose harvests last for shorter periods in a season are more likely to use coping than adaptation strategies and that female headed households, who were found to be more vulnerable are less likely to adapt unless measures such as increasing access to information and technologies are put in place. Such strategies used as a way of coping in Lupane and Lower Gweru include borrowing food and cash and eating food not normally eaten (treated seed stock). Most importantly, this study concludes that factors influencing adaptation do not act in isolation as individual factors but rather as a combination of related factors.

6.3 RECOMMENDATIONS

This section outlines recommendations that follow from the analysis and results of this study. This study recognises that there is some research that has already been conducted on climate change adaptation in Africa to date, hence there is some progress that has been made in understanding and making recommendations for policy makers in addressing climate change impacts. However, little research on this subject has been conducted in the selected study areas and therefore this study may be important in providing recommendations in order to set a foundation for dealing with climate change in these areas.

❖ ***Recommendation One***

Strengthen the capacity of farmers and institutions for identifying and assessing climate changes through programmes to educate farmers and other relevant stakeholders on climate change and variability and their potential impacts on farmers' livelihoods

It is important for institutions, together with policy makers and researchers, to provide information that enables farmers to recognize and understand changes. This study also confirms that there is need for research methodologies that are sensitive to dynamics in farmer perceptions among communities, which are sometimes subtle and ambiguous. In addition, the fact that farmers may misconstrue causes of climate change to be purely natural as opposed to anthropogenic, may steer farmers away from the understanding that human activities play a critical role in accelerating changes in climate. In this regard, the need to design programmes that build on farmers' perceptions and design climate awareness campaigns cannot be overemphasised.

Future policies should also be aimed at strengthening institutions such as agricultural extension and meteorological services. Concerted and coordinated efforts of these and other relevant institutions should be geared towards increasing small-scale farmers' access to weather forecasts as a strategy to increase awareness and therefore preparedness for drought and flood occurrences, among other climate related shocks. To this end, development efforts need to be geared towards overcoming existing institutional obstacles and the inhibiting beliefs that support them and to diminish the barriers to access to weather forecasts.

❖ ***Recommendation Two***

Make a transition *from* designing policies that target climate change issues as a distinct entity *to* policies that address climate change issues as an integral component of multiple stressors that confront farmers

While progress has been made in understanding climate change impacts on farmers' livelihoods, a lot more still needs to be done in relation to understanding the role that other stressors play in compounding climate change outcomes. This study has highlighted that while climate change is at the centre of the challenges that farmers face, it is still imperative to consider farmers' challenges as being more intricate and diverse. In this study, the researcher dissected the stressors that farmers are confronted with and undertook to understand how critical these stressors are as perceived by the target farmers, bridging the gap between climate variability and multiple stressors and corresponding adaptations.

This study also recommends for improvements in health care, education, infrastructure and governance, all of which have the potential to improve society's resilience to a number of shocks and trends and also improve resilience to the impacts of climate variability and change. In this respect, this study recommends that there is need for governments to fast track agricultural programmes and services such as provision and rehabilitation of dip tanks and boreholes in order to address problems that include livestock disease and shortages of water for both people and livestock. It becomes important for future policy to address climate related problems as part of a web of problems farmers are confronted with. The identification of a number of factors affecting farmers in the study areas gives an indication of how complex these factors are.

❖ ***Recommendation Three***

Design appropriate policies that buttress farming systems against climate variability and change through taking into account variations in these farming systems and other relevant factors

It is important to acknowledge that while some polices may work across all locations, others may need to be specifically targeted for certain areas. While this study highlights how critical general economic development will be in reducing the vulnerability of farmers and farming systems to climate change and to increased frequency and intensity of extreme events, it is imperative to design policies that are targeted for specific variations in geographic location and other factors.

Significantly, early warning systems of extreme weather conditions can contribute to ensuring that farmers from all locations are warned in advance and take appropriate measures to deal with these climate extremes. The implication for policy herein is that relevant institutions need to be well informed of such threats that climate variability may pose to health for both people and livestock and for them to be well equipped during these periods so as to be able to deal with emerging cases. The issue of early warning systems also becomes important at such times to increase the level of preparedness on these institutions. These institutions may include the veterinary, meteorological and agricultural departments and human health delivery stakeholders. In this regard, this calls for appropriate government polices that take into account concerted and collaborative efforts between these stakeholders and institutions, together with the target farmers.

However, specific policies may need to be more localised, based on the specific farming systems and other factors that may be social, economic or environmental. For instance, there is a need for future policy to address issues such as all year irrigation in better watered districts such as Monze (Zambia) and Lower Gweru (Zimbabwe) in order to ensure that there is food security and access to income for these farmers throughout the year. This policy would not be appropriate for the drier districts. Similarly, water harvesting techniques can be designed in consultation with farmers in drier areas so that they are better prepared to address unavailability of water due to droughts. This would in turn influence ecological and economic processes which are to a greater or lesser extent limited by water availability. Therefore, it is important to align agricultural and socio-economic policies with the realities of environmental factors that characterize each location.

- ***Recommendation Four***

Make a transition *from* conceptualisation of climate change impacts in the policy framework as being inherently negative, *to* research and policy making with an open-minded lens that dissects climate change and variability impacts in order to enhance alternative livelihoods for farmers

Most of previous research on climate change has made recommendations based on the conceptualisation of climate change as being negative alone. This study recommends that in addition to the current conceptualisation, there is need to go a step further and consider any positive impacts or localised benefits that might arise from climate change and variability in certain situations. This study suggests that it would aid future policy making with regards to addressing climate change impacts by taking into account the positive impacts and building on them to improve the livelihoods of small-scale farmers.

- ***Recommendation Five***

Provide support for appropriate agricultural innovations and development of new livelihood activities emerging as farmers respond to climate variability and change

While there have already been efforts to strengthen farmers' agricultural practices through promotion of conservation agriculture for instance, there is growing consensus that there is need to focus policy and development interventions on mobilizing knowledge and information to support a continuous process of innovation. The innovation process encompasses using knowledge and information to create new products and strategies that satisfy social and economic goals.

However, what still appears to be problematic is that this process has been initiated with an emphasis on research and extension, which have fallen short by not fully taking farmers on board (Njuki *et al.* 2008). This study recommends that the thrust of the innovation process should fall more on interventions that build on farmers knowledge by providing these farmers with the necessary information such as on markets and weather. The study further recommends that there is need for governments through relevant departments to strengthen patterns of interaction between farmers and extension and to provide extension services that strengthen farmers' capacity and indigenous knowledge in agronomic practices. At the same time, there are higher demands for adaptation due to changing climate, as well as by local economic and social development demands that traditional strategies be improved and strengthened. Given that agriculture has been found to be the basis of the economies of these farmers, there is also need for future policy to come up with subsidies that enhance agricultural production for these subsistence farmers.

In addition, it is critical for concerted and collaborative efforts to also address the issue of livelihood diversification and related issues such as accessibility of agricultural markets in order to enhance food security for farmers in times of shocks such as climate induced droughts. In this regard, it is important for future policy to create space for livelihood diversity, for instance by strengthening small-scale mining for farmers in Zimbabwe districts who have had significant contribution to their livelihoods from gold panning.

❖ ***Recommendation Six***

Integrate sectors through interventions that target agricultural extension, meteorology, academic research and other developmental activities through civil society organisations

While farmers may inherently respond to changes in climate that may affect their crop and livestock productivity, this study has found that factors such as demography, access to information and assets, the vulnerability context and farmers' perceptions, among others, do influence whether these farmers will cope or adapt to climate changes. While there is evidence to show that action research and intervention programmes have already started to take farmers on board by engaging them in farmer field schools and innovation platforms, this study recommends that there is need to strengthen these activities into fully fledged innovation activities that build on farmers' indigenous knowledge and capabilities as highlighted under Recommendation Five. In addition, understanding the factors that influence household choice of adaptation options can provide policy insights for identifying target variables to enhance the use of adaptation measures in agriculture.

In summary, this study has demonstrated that detailed empirical and context-specific research using case studies can add to our understanding of the processes of adaptation and the factors that limit adaptation for some members of society. This study attests through these case studies that analysis of perceptions of climate variability and change and their impacts and adaptation at a local level, as well as establishing a broad understanding of the dynamics of the livelihood strategies on which people depend, can provide insights into social adaptation and resilience to climate impacts.

In essence, the results of this study, based on the first objective, lead to the main conclusion that farmers perceptions of climate variability and change are shaped by factors which may be political and socio-cultural. With regards, to the second objective, it is concluded that climate change impacts are overwhelmingly negative although there may be some positive impact under certain circumstances. These impacts are compounded by a host of other challenges that may be linked to the general political and socio-economic factors in a country. In addition, results for objective three indicate that farmers have started to significantly respond to climate change impacts, which are considered by farmers to be paramount among other challenging factors. Responses to these impacts have been in the form of both short-term and long-term measures, which have temporal and spatial variations. Also under objective three, it is concluded that the way farmers respond to climate changes is influenced by both internal and external factors that include among others, demography, access to information and assets and these farmers vulnerability context.

6.4 KEY POINTS FOR FURTHER RESEARCH

While the SLA provides a framework in which to understand capital assets and policy and institutional processes and their role in cushioning farmers against impacts from climate change, it was beyond the scope of this study to undertake a comprehensive analysis of these assets in the study areas. This was due to limitations of time and resources for a study of this nature. In this respect, it would be interesting for future research to have an in-depth analysis of these capital assets vis a vis impacts from climate variability and change. In addition, further detailed research is needed in this regard to dissect the extent to which these five capital assets as espoused by the SLA influence farmers' adaptive capacity.

This study leaves a gap for future research in understanding in detail livelihood outcomes emanating from use of each coping and adaptation strategy identified. This will be important to understand to what extent a diversity of coping and adaptation strategies are able to contribute to successful adaptation. A diverse mix of livelihood activities may not, on its own, be enough to provide a household with resilience to climatic stresses. Therefore it is important not to assume that livelihood diversification makes people resilient to climate impacts.

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APPENDIX A

FARMER STRATEGIES TOWARDS CLIMATE VARIABILITY AND CHANGE IN ZIMBABWE AND ZAMBIA

Questionnaire for Data Collection

SECTION A: GENERAL INFORMATION

Enumerator ____________________________Date ________________________

Country: 1=Zimbabwe 2=Zambia
District: 1 = Monze, 2 = Sinazongwe 3= Lupane 4= Lower Gweru
Agricultural Camp Ward: 1 = Njoola, 2 = Mujika, 3 = Sinazeze, 4 = Sinamalima, 5= Menyezwa, 6=Daluka, 7= Nyama, 8=Mdubiwa
Village : ____________________________
Name of household head (HH)____

SECTION B: AGRICULTURAL PRODUCTION

How much land do you own and cultivate?

	Last year	5 years ago	If there is a change, reasons for the change	Tillage method commonly used 1=Manual with hoe 2= Animal traction 3= Tractor tillage
How much land do/did you own (acres)				
How much land do/did you cultivate (acres)				
Area not being utilised (acres)				
Do/did you hire additional land / plots *(1=yes; 0=No)*				
If yes, how many acres? (acres)				

How much land on irrigation(acres)				

What are the priority crops grown now and five years ago?

Crops grown currently		Crops grown five years ago		
Crops grown now	How important is the crop for food security (see codes below)	Crops grown five years ago	How important was the crop for food security (see codes below)	If there is a change in priority of crop, why?

Codes for importance of crop 1=Very importance 2=Moderate importance 3=Not important

a) What are the indicators of a good crop production year?

Indicator (e.g. rainfall)	Description (quantify if possible)

b) In the last 10 years, which years would you consider as having been good? ....

a) What are the indicators of a poor crop production year?

Indicator (e.g. rainfall)	Description (quantify if possible)

b) In the last 10 years, which years would you consider as having been poor? ....

What management practices, if any, do you use to manage the uncertainty (unreliability) of seasonal rainfall?

Description of practice	When do you use it? 1=Good Year 2=Bad Year	On what crops?	On what area?

What are the average yields for the following major crops in a good crop production year and a poor crop production year?

	Home Fields		Outfields	
Crop	Amount (in Kg)/ acre in a good crop production year	Amount (in kg) / acre in a bad crop production year?	Amount (in Kg)/ acre in a good crop production year	Amount (in kg) / acre in a bad crop production year?
Maize				
Millet				
Sorghum				
Groundnuts				
Other 2				
Other 3				

In the last 5 years, what has been the change in production of the following crops?

How would you rank the changes you have mentioned above in terms of their contribution to change in agricultural productivity?

Causes of decline in crop production (NB-Enumerator to transfer causes from the table above)	Rank these factors (starting with 1=most critical, 2= second most critical, etc)

What improved or local technologies are you currently using in crop production and what are the objectives of using them?

Technologies being used (if local names are given, please describe the technology)	On what crops are you using them?	When did you start using them?	What are the objectives for using them or what problems are you trying to address by using the technologies?

What are the main changes that you have made in the way you farm in the last ten years?

a) Things that you are doing now that you were not doing before

Changes	When did you make the	Why did you make the

	changes?	changes?

b) Things that you were doing before and have now stopped

Changes	When did you make the changes?	Why did you make the changes?

SECTION C. HOUSEHOLD INCOME AND CAPITAL ASSETS

What are your main sources of income in the past year and how important are these sources to your livelihood?

Income Source	Yes/No (a)	Priority
Sale of crops		
Sale of livestock		
Informal work *(maricho)*		
Formal employment		
Remittances		
Old age pension		
Pension fund from work		
Gifts received in kind		
No income at all		
Gardening		
Brickmaking		
Others (specify)		

Codes: Yes=1, No=2

What livestock do you own?

Assets	Do you own? 1= yes 2=no	If yes, how many?	Source: 1=bought, 2=gift, 3=inheritance, 4=other source	Purpose for keeping 1=Mainly for food 2=Mainly for cash 3=Equally for cash and food 4=For asset accumulation / prestige

				etc
a. Cattle				
b. Goats/ Sheep				
c. Poultry (chickens, guinea fowls)				
d. Donkey				
e. Pigs				
Other (specify).................				

What major agricultural assets/implements do you have?

Assets	Do you own 1= yes 2=no	Number	Source: 1=bought, 2=gift, 3=inheritance, 4=other source
a. Ox-drawn plough			
b. Oxcart			
c. Harrow			
d. Ridging plough			
e. Cultivator			
f. Irrigation equipment (e.g. treadle pump, water pump, etc) Other (specify)........................			
g. Sprayer			
h. Hoes			
i. Ripper			
j. Axe			
k. Planter			
l. Other (specify)			

19. What major domestic assets do you have?

Assets	Do you own? 1= yes 2=no	If yes, how many?	Source: 1=bought, 2=gift, 3=inheritance, 4=other source
a. Radio/TV			
b. Bicycle			

c. Mobile phone			
d. Sewing machines			
e. Watch/clock			
f. Paraffin stove			
Other (specify)			

SECTION D: FARMER PERCEPTIONS OF CLIMATE CHANGE

Have you noticed any significant changes in weather patterns over the years in relation to agriculture? ***0=no, 1=yes***

20. If **YES**, what changes have you observed and what do you think are their causes? (Probe for changes and tick where appropriate and add any others that the farmer mentions)

Changes	Tick if farmer mentions	How many times have you witnessed them in the last 5 years?	What do you think are the main causes of these changes?
Increased number of seasons without enough rainfall			
Increased floods			
Rainfall starts late and ends early			
Extremes in temperatures (e.g. very cold winters/frost/very hot summer			
Long dry spell			
Rains come earlier than they normally should			
Other			

21. For the changes mentioned above, what are some of their impacts in your household, the environment etc

	What are the impacts of these changes to your household/ livelihoods?	What are the impacts you have observed of these changes on the environment?
Increased number of seasons without enough rainfall		
Increased floods		
Rainfall starts late and ends early		
Winters have become colder		
Summers have become hotter		
Long dry spell		
Rains come earlier than they normally should		
During the season, the rainfall is not consistent		
Other 1		

22. If any of these occurrences happens what actions do you take related to agricultural production?

Change	What action do you normally take
Increased number of seasons without enough rainfall	
Increased floods	
Rainfall starts late and ends early	
Winters have become colder	
Summers have become hotter	
Long dry spell	

Rains come earlier than they normally should	
During the season, the rainfall is not consistent	
Other	

Do you have access to the weather forecasting data/information? ***0=No, 1=Yes***

If yes, what different kinds of information do you get and where do you get it from?

Type of information	Source of information 1=Radio, 2=Extension 3=Fellow farmer 4=Television 5=other (specify)

How would you rate the weather information that you receive?

	Rating 1=Poor, 2=Average 3=Good	What are the reasons for your rating?	What are your suggestions for improvement?
Timelineness			
Adequacy			
Frequency of dissemination			
Usefulness			
General content			
Delivery channel			
Language of presentation			

26. If the forecast information is positive i.e it predicts that the rainfall will be enough and will be on time, what are some of the actions that you take in your farm?

Action	Do you take this action? *(tick if farmer mentions)*	Why do you take this action?

27. If the forecast information is negative i.e it predicts that the rainfall will not be good or reliable, what are some of the actions that you take in your farm?

Action	Do you take this action? *(tick if farmer mentions)*	Why do you take this action?

Do you have any traditional / indigenous ways of predicting the weather patterns?

Weather pattern	Prediction Indicators
Drought Year	
Normal year (Rainfall)	
Flood Year	
Very cold winters	
Normal winters	
Very hot summer	
Normal summer	

What are the trends that you have observed in the following in the last ten years?

Variables	Increased *(tick)*	Same (tick)	Declined *(tick)*	What would you say is the main causes of this change?
Crop yields				
Crop types, varieties				
Crop pests and diseases				
Livestock populations				
Livestock diseases				
Quality of pastures				
Rainfall amounts				
Water availability (for				

domestic use)				
Soil erosion				
Water erosion				
Wind erosion				
Income from agriculture				
Food availability for household consumption				

For those variables where there has been a change, how are you coping with these changes?

Variables	How are you coping with change?
Crop yields	
Crop types, varieties	
Crop pests and diseases	
Livestock populations	
Livestock diseases	
Quality of pastures	
Rainfall amounts	
Water availability	
Soil erosion	
Water erosion	
Wind erosion	
Income from agriculture	
Food availability for household consumption	

Are you using any of the following farming practices in your farm as a result of the changes in weather patterns?

Farming practice	Do you use? ((Tick as if farmer mentions)	When do you use? 1=All the time 2=During drought years 3=During good rainfall years
Potholing		
Ripping		
Crop residues		
Chemical weed control		
Tied ridging		
Winter ploughing		
Conservation basins		
Using drought tolerant varieties		
Changing crops		

Mulching		
Intercropping		
Mono cropping		
Fallowing		
Other		

Are there some crop production practices that you use in good rainfall years and avoid in drought years? If yes, which ones

Cropping practice	Do you use in good rainfall years? 0=No 1=Yes	Do you use in drought years? 0=No 1=Yes	Reasons
Use of fertilizers			
Use of cattle manure			
Hire of labour for farming activities			
Use of irrigation			
Purchase of improved seeds			
First weeding			
Second weeding			
Other			

SECTION E: VULNERABILITY AND CLIMATIC RISK MANAGEMENT

33. How long does the main harvest last in a good and bad year and how do you fill these shortages?

	Number of months harvest lasts	Strategies the household uses to cope with shortage
Average good year		
Average bad year		

34. During which month last year (2007) growing season did your household have enough or shortages (*Indicate the food availability trend across the year by* ticking either enough or not enough)

Month	Enough	Not Enough	Month	Enough	Not Enough
January			July		
February			August		
March			September		
April			October		
May			November		
June			December		

Which of the following can you say was true for your household at any point in time during last year as a coping strategy for food shortages? (Tick appropriate box)

	1 = Yes	2 = No
Sold livestock		
Sold household assets		
Consumed seed stock		
Ate food that we normally don't eat (e.g wild food)		
Reduced amount of food eaten		
Ate fewer meals per day		
Sought daily work for cash outside farm		
Migrated		
Borrowed cash to buy food		
Borrowed food		
Worked in other peoples farms for food		
Sold firewood		
Rented out land		
Withdrew children from school		
Looked for relief		
Other (specify)		

SECTION F: GENDER, SOCIAL AND HUMAN CAPITAL

Which trainings have you received on agricultural production the last 3 years?

Topic of training	Who organised the training?	Who attended the training 1=Husband; 2=Wife; 3= Both	How did you use the knowledge/ skills? 1=Applied on my farm; 2= Trained others; 3=other............. 4=Applied on my farm and trained others

37. How would you assess your ability to do the following?

	How would you assess your ability, **currently?** 0=Not good 1= good 2=Very good
Interpret weather information	
Use weather information to plan for the season	
Determine which practice to use during drought years	
Determine varieties of crops to plant for different conditions e.g drought , flood etc	
Train other farmers on how to use weather information	
Keep own farm records	

38. Are you currently a member of any farmers' group or local association in this village? If yes, give the name

Name of group or association (*include local institutions*)	Type of group (1 = Mixed, 2 = Women's, 3 = Men's)	Your position in the group (1 = Committee member, 2 = Ordinary member)	How long have you been a member of this group? (*in years*)

SECTION H: DEMOGRAPHIC CHARACTERISTICS

		Codes	Response
H1.	Sex of household head	1= male 2 =female	
H2.	Wealth rank category (Household perception)	1= Poor, 2= Medium, 3= Rich	
H3.	Age of household head (Actual number of years)		
	Age of household spouse *(Actual number of years)*		
H4.	Marital status of household head	1=married 2=widowed 3=divorced 4=single, 5=polygamist	
H5.	Household head's farming experience in years		
H6.	Education level of household head	1=none, 2=primary, 3=secondary, 4=tertiary	
H7.	Position of household head in the community	1=ordinary citizen 2=head man 3=religious leader	
H8	Other occupation of head of household head	1=Business 2=Teacher 3=Other self employment	
	Type of house	Roof (1=Thatch 2=Iron tin roof 3=Tile)	
		Walls (1=Mud and sticks 2=Unburnt brick 3=Burnt brick 4=Wood 5=Stone	

i. Is there anything you would like to share with me pertaining to weather changes/climate change?

____

____

____

____

APPENDIX B

FOCUS GROUP DISCUSSION

Key objectives

- Discuss community livelihood strategies, constraints and opportunities
- Gain an in-depth knowledge of the farming system as it relates to the semi-arid areas of Zambia and Zimbabwe
- Get preliminary information / insights into farmer perceptions of climate change and variability
- Document the common adaptive and coping strategies in Zambia and Zimbabwe
- Analyse the extent to which coping and adaptive strategies differ in the two countries

Methodology description and information requirements

1. Establishing dialogue and setting social contract

- Who are we?
- Why are we here?

2. Community Livelihood strategies, constraints and opportunities

Tools to Use

a) The river Code:

Results: A community livelihood vision

b) Resource Mapping: From the community vision, the nest question is-what resources or what opportunities exist in our communities to enable us reach our vision. The resource map was extended to include issues of

- Access to different resources by different socio-economic groups in the community
- Trends in changes of the resources and reasons for the changes (this may or may not have links to climate variability and change!!)

Results

- All the resources that the community has at its disposal
- Differences in access to the resources (men / women and other socio-economic groups)
- Trends in changes in resources for the last decade and reasons for these trends

c) Opportunity and Constraint analysis: Brainstorming and Scoring / Ranking

What are the opportunities for improving livelihoods?
What are the constraints to improving livelihoods?
What are the communities' worst fears?

NB: is climate variability and change a key constraint? How does it rank against other constraints in the two countries?

3. Gain an in-depth knowledge of the farming system as it relates to the semi-arid areas of Zambia and Zimbabwe

Tools to use
a) Brainstorming
b) Scoring and Ranking
c) Use of secondary information

Results

- Priority crops/ livestock
- Main reason for growing crops / keeping livestock
- Types of cropping and crop-livestock systems
- Constraints and opportunities for different crops/ livestock / systems

    - In addition, probe for gender issues using seasonal calendars and daily activity calendars to understand the gender issues, gender division of labour, decision making and knowledge

4. Institutional Mapping
What institutions exist in the area (probe for both formal and informal),
What kind of support does each institution provide?
Relevance in the context of food security, climate change issues and local livelihoods

Tool
A network mapping of organizations working in the area, their functions and interrelatedness

5. Get preliminary information / insights into farmer perceptions of climate change and variability
At this stage, issues of crop failure, drought, famine, floods etc that are related to climate change and variability may have come up in the last 3 sessions. If they have, the aim is to

build on them to establish a trend of how these have occurred or changed in the last one or two decades.

Tools to be used

a) Trend lines

To establish in the Ist to decades, what are the major events / occurrences that have occurred that are related to the community resources, rainfall and general climate, and even political situation. What occurrences had the greatest impacts on the community?

b) Brainstorming and Impact diagrams

From a above, pick climate / or weather related activities and draw some impact diagrams of the impacts that occurred as a result of these events. This is a cause and effect diagram that tries to links certain events with their consequences in a logical manner

6. Document the common adaptive and coping strategies in Zambia and Zimbabwe

For this, build several scenarios; a) that there are signs that it will not be a good season c) there are signs that it will be a really good season d) We really cant tell what kind of season it is going to be

Tools to use

a) Brainstorming

- What tells us whether it will be a good season? What are the signs?
- What tells us it will be a bad season? What are the signs?

b) Brainstorming in small group sessions

-