Adaptation of Farmers to Climate Change in Ohangwena Region, Namibia

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ABSTRACT

This study aimed to establish an understanding of the local adaptation and coping mechanisms in relation to flood impacts on agriculture in the Ohangwena Region. This was necessitated by the fact that the region experienced heavy floods between 2008 and 2009, which are attributed to climate variability and change in Namibia. Nevertheless, since the region also experiences drought as a result of climate variability, the study has lightly touched on them, however, it mainly paid particular attention to the floods.

In general, climate in Namibia is variable, with increasing variability in temperature and rainfall patterns. As a result, rural communities in northern Namibia have become vulnerable to climate variability. The latter mainly depend on agriculture for subsistence, the source of food security which is vulnerable to the climatic events of floods and droughts. One of the major factors that have contributed to communities' vulnerability to floods is the fact that many farmers have settled in flood prone areas. With the realization that rural communities are vulnerable to the two climatic events, it was deemed necessary to identify the coping strategies currently in place in order to strengthen them. This will help the communities to be able to respond to the changing environmental circumstances in the long-term. Enhancing the adaptive capacities for communities to respond to the impacts of climate variability and change on agriculture has also been considered essential by this study. Consequently the study placed some efforts in proposing future adaptation strategies for climate change, which will allow farmers to effectively address the impacts of climate change in future. This was made possible by consultations with farmers in four constituencies in the Ohangwena Region, namely: Eenhana, Endola, Odibo and Ongenga, through focus group sessions. The farmers in these constituencies shed some light on the climate variability within the region, on the impact of climate variability and change on agriculture, as well as on the coping strategies that are currently being implemented within the region.

The reality of climate variability and change has been noticed by farmers in Ohangwena Region. Variability in climate patterns mainly results in affected rainfall patterns and in increasing atmospheric temperature. Rainfall is received during the late months of the year (October – December), and the early months of the year (January – April). However, there is a difference in the amount of rainfall received in those months. High amount of rainfall is received during the early months of the year compared to the amount received during the late months of the year, which in fact do not support grown of agricultural crops.

The major impacts of floods on agriculture in the region are mainly: destruction of crop fields, livestock losses, destruction of households, loss of infrastructure, pest outbreaks, reduced soil fertility, reduction of crop yields, destruction of crop fields, poor rangeland conditions, diseases and loss of human and animal lives. At the moment, the coping strategies being implemented in Ohangwena Region to address the impact of climate change are very weak; therefore they need to be strengthened.

The lessons learned during this study have been documented. This study has also made some recommendations around the implementation of the proposed adaptation strategies, on the possibility of increasing awareness about the reality of climate variability and change within the region, and on avoidance of settling in flood prone areas. The study has concluded that the regional capacity can be enhanced.

DEDICATION

This thesis is dedicated to my parents Mr Veikko Hasheela and Mrs Hilja Hasheela. Thank you very much for your unending love and care.

DECLARATION

I hereby declare that the thesis hereby submitted for the Masters in Development Studies at the University of the Free State is my original work, which to the best of my knowledge has not been submitted to any other university for the purpose of awarding a degree. Where the work of other authors has been used, it has duly been acknowledged. I hereby concede copyright to the University of the Free State.

Raili L. Hasheela
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ACRONYMS AND ABBREVIATIONS

ENSO	El Ninõ/Southern Oscillation
EWS	Early Warning System
FEMCO	Flood Emergency Management Coordination Office
ITCZ	Inter-Tropical Convergence Zone
OFDA	Office of U.S. Foreign Disaster Assistance
PoN	Polytechnic of Namibia
PRA	Participatory Rural Appraisal
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNAM	University of Namibia
US	United States
USAID	United States of Agency for International Development

CHAPTER 1: INTRODUCTION

1.1. Background

It is universally accepted that climate has changed and is ever changing. Evidence is available that proves the reality of climate change (Boko *et al*., 2007; Burroughs, 2001; Feddema, 1999; Hulme *et al*., 2000; Huq *et al*., 2006). Climate change can be defined as shifts in meteorological conditions over the years (Burroughs, 2001). Such shifts can be noticed by observing changes in parameters such as temperature or rainfall, which result in changing weather patterns such as cold, wet, dry, cloudy and windy conditions. Other notable signs include extreme weather events such as floods, droughts and storms (Boko *et al*., 2007; Mirza, 2003). Climate change can also be defined as a change in the mean state of the climate or its variability, persisting for several decades or longer (CCIR, 2004). Continuous changes in the climate are known to be caused by global warming, which is said to cause changes in the global climate; including changes in rainfall, temperature, wind patterns and ocean currents (RIC Publications, 2007).

Although climate change occurs as a result of global warming, it is said to be induced by human activities (O'Brien *et al*., 2006). Changes in the amount of greenhouse gases in the air that have occurred naturally during the history of the earth are known to be the cause climate change (RIC Publications, 2007). As far as development is concerned, anthropogenic greenhouses gases are said to be the main drivers of climate change (UNEP, 2007). Land-use practices are some of the human activities that drive atmospheric emissions, such as emissions of CO^2, articulate matters and other pollutants (UNEP, 2007). In addition to greenhouse gases, climate can also be affected by other agents, some of which are the aerosols, which are suspended in the atmosphere and have a cooling effect on climate (Hulme *et al*., 2000). In general, factors such as land-use

changes, increasing pressure on resources, pollution and emission of greenhouse gases alter the environment (Miller, 2007). As a consequence, major changes such as desertification, deforestation, biodiversity loss, changes in soil moisture and soil degradation are experienced. Such changes can significantly impact on climate (Burroughs, 2001; Feddema, 1999). Apart from human's alteration of earth's surface, other factors such as El Ninõ[1]/Southern Oscillation (ENSO) are known to affect rainfall patterns in Africa. These are related to greenhouse gas induced global warming (Hulme *et al*., 2000).

Africa in particular is known as one of the most vulnerable continents to climate change and variability (Boko *et al*., 2007; Hulme *et al*., 2000). According to Hulme *et al*., (2000), Africa's climate has become warmer than it was over the past century. Climate warming is attributed to greenhouse emissions, which is increased by human activities (DFID, 2004; Hulme *et al*., 2000; Midgley *et al*., 2005). Such a warming causes changes in the atmospheric temperature, which has some impacts on the climatic conditions such as atmospheric circulations, precipitation rates and in atmospheric processes such as evaporation and transpiration (Feddema, 1999). As a result of changes in climatic conditions, changes in climate patterns are observed. Consequently, various changes and undesirable results are experienced. These include: changes in runoff and water availability, droughts, floods and significant livelihood impacts (Boko *et al*., 2007; FEMCO, 2009). For this reason, climate change has become a threat to human development.

The real vulnerabilities to climate warming are said to be more concentrated in the developing countries, particularly in the rural communities (HDRO, 2007). The major economic sectors in Africa are said to be vulnerable to climate sensitivity, and this sensitivity is accelerated by existing developmental challenges, which have contributed to Africa's weak adaptive capacity – further

[1] El Ninõ is a large-scale ocean-atmosphere climatic event that results in a striking warming in sea-surface temperatures across the equatorial Pacific Ocean, on average every five years. A few months after such an event, an increase in the global average temperatures is experienced.

increasing the continent's vulnerability to projected climate change (Boko *et al*., 2007). In southern Africa, increasing temperatures have been experienced in Namibia, Zambia, Botswana and Mozambique (New *et al*., 2006). This warming climate exerts pressure on rural people's livelihoods, as well as on resource availability and accessibility (Boko *et al*., 2007; Hulme *et al*., 2000). Climate change can also impact issues that affect humans such as poverty, health, hunger and their immediate environments. Consequently, the affected people have to learn to adapt to the changing climate. For this reason, adaptation strategies need to be developed and implemented. Adaptation refers to the ability to respond to the changing climate or any environmental circumstances for long-term survival (Schipper *et al*., 2008). Nevertheless, adaptation may involve processes that can bring along some challenges. According to Sperling (2003), adaptation is successful if it is reducing vulnerability of poor people to existing climate variability. Therefore, in order to develop adaptation strategies for climate change, it is worthwhile to consider the vulnerability to climate variability, as well as future climate change (DFID, 2004; Schipper *et al*., 2008). Moreover, understanding the climate patterns will contribute to the development of effective adaptation strategies.

The climate in Namibia is said to be variable, with increasing variability in temperature and rainfall patterns (New *et al*., 2006; Midgley *et al*., 2005). Many parts of Namibia have become vulnerable to climate variability; especially the rural areas (Dirkx *et al*., 2008). Factors contributing to people's vulnerability include: floods, droughts, dependency on agriculture, household income, unemployment, poverty and health status (Adger *et al*., 2003; Huq *et al*., 2007). It is important to note that vulnerability to environmental change does not only depend on the duration of the climatic conditions but also on the capacity to respond adequately to those changes (Dirkx *et al*., 2008). Namibia has recently experienced extreme floods, following some years of drought. The latter are attributed to climate variability (Dirkx *et al*., 2008; Nunes *et al*., 2010; Olziewski, 2010). In essence, impacts of the common climatic events on community

development need to be investigated. This is due to the notion that such events contribute to increased vulnerability among communities (DFID, 2004). Additionally, understanding the impacts of climate change influences the adaptation interventions. In the view of the extreme flood events, it is imperative that the coping strategies currently in place need to be identified, as the knowledge of coping strategies is necessary for the development of adaptation strategies (Schipper *et al*., 2008). Coping strategies refer to short-term strategies to respond to the changing environmental circumstances.

In the context of socio-economy, rural communities in Namibia are more vulnerable to climate change given their heavy dependence on the climate as the basis for their livelihoods (Dirkx *et al*., 2008). Their vulnerability is influenced by the fact that many of them are living in poverty, and have lack of income-generation and employment opportunities. With this notion, it is ideal to assess how climatic events impact the rural areas in Namibia. It is also essential to identify the coping strategies currently in place, in order to propose possible future adaptation strategies. This research is, however, specific to selected constituencies in the Ohangwena Region, northern Namibia.

1.2. Problem Statement

Namibia is an arid to semi-arid country and as a result it is characterized by a variable climate (Barnard, 1998; Dirkx *et al*., 2008). Climate change predictions speculate that climatic variability in Namibia is on the increase as a result of global warming (Midgley *et al*., 2005). Poor communities in Namibia are commonly hardest hit by climatic disasters because of their limited coping strategies. Between 2008 and 2009, the country experienced severe floods in the northern regions. Among others, rural communities disproportionately suffer the consequences of floods. Reasons for this are more related to socio-economic issues (Nunes *et al*., 2010). Most rural communities settle in flood prone areas, therefore they become more vulnerable to floods due to limited financial

capacities to respond to the impacts of floods. In addition, they have limited coping strategies.

Looking particularly at the Ohangwena Region, the risk of climate change on agriculture is quite high; especially that a large proportion of the population there depends on subsistence farming for livelihoods. The majority of the people living in Ohangwena heavily depend on subsistence agriculture, in which small-scale millet 'omahangu' cultivation and cattle keeping are the major primary sources of livelihoods (NPC, 2004). It is known that rural communities have mechanisms in place to cope with the variations in climate (Sperling, 2003). It is also expected that as variability increases, there will be a need to strengthen the coping strategies which are often immediate short-term solutions so as to put in place adaptation measures that are more sustainable. Given the fact that the Ohangwena Region has recently experienced severe floods that are attributed to climate variability/change, it was thought to be worthwhile investigating how its main source of livelihoods i.e. agriculture is impacted, to assess how communities cope with the flood impacts in terms of agriculture and to assess farmers' vulnerability to floods.

The recent floods can be attributed to climate change due to its known influence on the annual rainfall, which can impact runoff and drainage in perennial rives and wetlands in northern Namibia (Dirkx *et al*., 2008; New *et al*., 2006). Some parts of the Ohangwena Region in northern Namibia fall under the Cuvelai drainage system, which is fed by a number of rivers and causes flooding during heavy rainfall (Mendelsohn *et al*., 2000). It is evident that the recent floods were experienced during the rainy season (Hiyalwa, 2009; OPM, 2008). A study conducted by New *et al*. (2006) has also shown that there are some trends in the rainfall intensity. Nevertheless, although there is no degree of certainty that the climate has changed, studies of historical trends have revealed that the climate in Namibia is variable (Dirkx *et al*., 2008). However, climate is likely to be changing in Namibia (Midgley *et al*., 2005). As a result, communities become vulnerable to

climate variability, as it causes changes in environmental conditions such as floods and droughts (HDRO, 2007). Vulnerability to climate variability requires societies to have adaptive capacities, which in fact prepare them to be adaptive to climate change in case it occurs (Dirkx *et al*., 2008).

This study aimed to establish an understanding of the local adaptation and coping mechanisms in relation to flood impacts on agriculture in the Ohangwena Region, due to the floods that have lately been experienced. It has used four constituencies as the focal study areas. The study has documented the lessons learned from the four selected constituencies and has made recommendations to enhance the current coping and adaptation strategies. It has further developed an understanding of climate patterns and investigates the extent of climate change/variability impacts on agricultural practices within the communities. It also assessed the regional vulnerability to floods. Overall, the study attempted to answer the following questions:

- *What type of coping strategies are currently in place?*
- *How are the coping strategies currently in place helping poor farmers to survive the impacts of floods?*
- *How can such coping strategies be strengthened?*
- *How can the existing adaptation measures address the long-term impacts of floods on agriculture in future?*
- *How can the Ohangwena Region maintain long-term adaptation strategies for dealing with floods*?
- *What lessons can be learned for other regions in similar conditions?*

1. 3. Research Purpose

1.3.1. Aim

The overall aim of this research was to explore and analyse existing adaptation measures to sustainably address the impacts of floods on agriculture in Ohangwena Region for the long-term, in order to enhance regional capacity to adapt to climate change.

1.3.2. Objectives

The specific research objectives were to:

- describe the climate patterns in the Ohangwena Region;
- assess the vulnerability of communities to floods;
- investigate the impacts of floods on crop and livestock farming in the region;
- identify the coping strategies currently in place in various communities within Ohangwena Region;
- explore and analyse existing adaptation measures;
- suggest mechanisms and interventions to strengthen the adaptation and coping strategies of the said communities; and
- document the lessons learned from four selected communities.

1.4. Conceptual Framework

The goal of this research was to explore and analyse the existing adaptation measures to sustainably address the impacts of floods on agriculture in Ohangwena Region for the long-term, in order to enhance regional capacity to adapt to climate change. Having reliable adaptation strategies in place will therefore help the communities in the Ohangwena Region to respond to floods and may be experienced in future. These will increase the adaptive capacity to the changing climate.

It is generally accepted that poor communities are more vulnerable to the impacts of climate change compared to any other group of people in the society (Agerup *et al*., 2004; Laukkonen *et al*., 2008). This is due to the fact that they lack access to services, including the basic ones. Once the poor communities become vulnerable as a result of climate change, pro-poor growth becomes difficult among such communities (DFID, 2004). Consequently, their capabilities to handle pressure caused by climate change become challenged. Against this background, it became necessary to assess the vulnerability of communities in the Ohangwena Region, following the recently experienced heavy floods.

In response to the experienced floods that are attributed to climate variability, it is expected that the communities in the region have to make some adjustments in behavior, livelihoods, or agricultural practices (Schipper *et al*., 2008). Responding to climate change however requires communities to be willing to change and to access appropriate technologies for adaptation (Tompkins & Adger, 2005). This means that possible long-term adaptation strategies for communal farmers in relation to floods need to be proposed, but should be agreed upon by the communities, to ensure that they respond to their needs. Nevertheless, long-term adaptation strategies can only be developed if the short-term strategies in place are known (Dirkx *et al*., 2008).

In actual fact, adaptation is not a stand-alone issue; therefore it should not be treated in isolation. Consequently, climate change adaptation should be addressed together with other environmental and socio-economic concerns that affect human development such as: poverty reduction, food security, water resources, disaster risk reduction, human health, public education and adaptation policies (Schipper *et al*., 2008; Sperling, 2003; Thompson *et al*., 2006). In addition, the issue of economic growth is worth considering when developing long-term strategies for adapting to climate change, particularly because it contributes to human well-being, livelihoods and people's quality of lives (Schipper *et al*., 2008). Therefore, it is essential that adaptation strategies for

future flood events in the region should consider both environmental and socio-economic aspects. Furthermore, it is important that communities' vulnerability to floods, flood management and adaptation strategies should be part of long-term sustainable development planning (Mirza, 2003).

The theoretical framework presented in Figure 1. depicts the theoretical areas that have been researched on in order to establish an understanding of the regional adaptive capacity to floods. Impacts of climate change on agriculture, adaptation and coping strategies implemented by communities, vulnerability and the climate patterns are some of the factors that have an influence on adaptive capacities to deal with climate change. Attempting to understand these factors has helped the researcher to document the lessons learned from the focal communities for this research, after which the future adaptation strategies were proposed. Having adaptation strategies in place will enhance the regional adaptive capacity to deal with climate change.

While the focus of this research is on how farmers in the Ohangwena Region cope with climate change, it was thought to be worthwhile to conduct a literature review on the relationship between climate change and agriculture. This review is presented in Chapter 2.

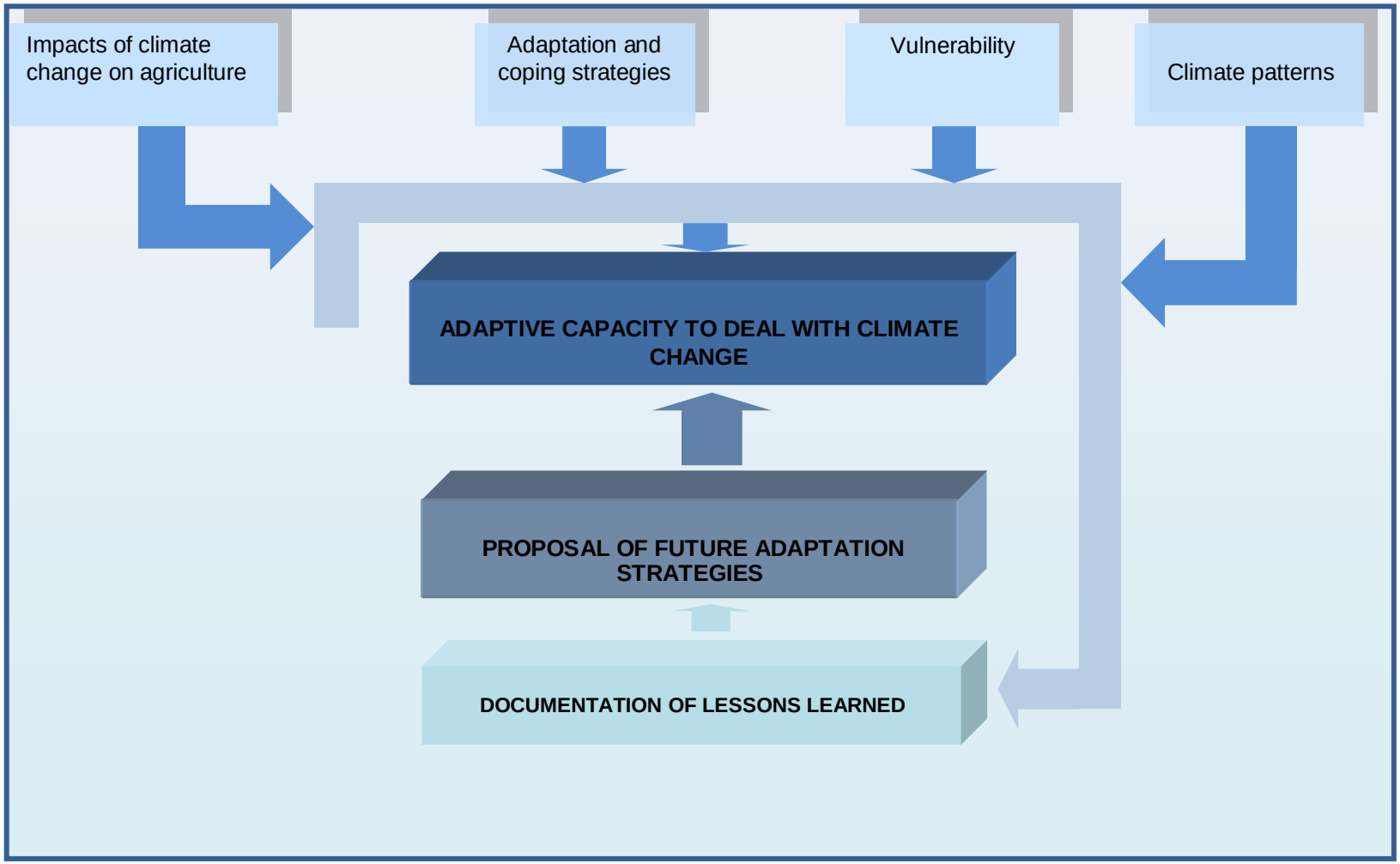

Figure 1. Factors that influence the adaptive capacity to deal with floods
(Source: Dirkx *et al.*, 2008; Sperling, 2003; Schippers *et al.*, 2008)

1.5. Synopsis

The information presented in this thesis is covered under 6 chapters. The first chapter presents the overall background to the research, which includes the problem statement, aim, objectives and the conceptual framework for the study.

Chapter 2 presents a literature review on the relationship between climate change and agriculture. It has taken a glance at how climate change impacts the developing countries in general, and has highlighted the climate patterns in Africa, with particular attention paid to the situation in Namibia. This chapter further looks at the vulnerability to climate change in general, and specifically in Namibia. In terms of vulnerability, it provides a view on the impacts of floods on agriculture, and the general impacts of floods on human development.

Chapter 3 presents a literature review on the adaptation and coping strategies for climate change. It has reviewed the issue of adaptation to climate change and has given a view of the adaptation and coping strategies available to address the impacts of climate change on agriculture. It has also looked at the factors to consider in order to increase the adaptive capacities with respect to climate change impacts.

Chapter 4 presents the research methodology employed for the purpose of this study. It has highlighted the research design, research site, target population, sampling strategy, sampling size, data collection approach, data capture and data analysis method used in this research. The limitations to this study have also been presented in this chapter.

Chapter 5 has presented the findings of this study and discussions of the findings. The findings revealed the evidence of climate variability in Ohangwena Region, impacts of climate variability in the region, coping and adaptation strategies in place, problems associated with climate change, and possible solutions to the experienced problems.

Chapter 6 presents the conclusion and recommendations made by this study.

CHAPTER 2: CLIMATE CHANGE AND AGRICULTURE

2.1. Introduction

Africa is said to be one of the most vulnerable continents to climate change (Boko *et al*., 2007). According to Stern (2006), Africa is expected to be severely affected by climate change. This includes many of the most vulnerable regions, one of which is southern Africa. Predictions have shown that there is a significant warming across the continent, which is expected to increase the precipitation rate, especially in Eastern Africa (Feddema, 1999). The study by Feddema (1999) has also revealed that global warming will be felt continent-wide in Africa. This is further supported by Stern (2006), who has indicated that southern Africa will not be left untouched by global warming. In addition, a warming climate in Africa is expected to place some pressure on water resources and to bring some changes in rainfall patterns (Hulme *et al*., 2001). In terms of agriculture, Africa is expected to suffer dramatic losses in agricultural productivity (IPCC, 2007; McCarl *et al*., 2001). Adejuwon (2005) indicated that monthly rainfall is the most powerful determinant of inter-annual changes in the crop yield than the total seasonal and annual rainfall. Studies have revealed that agricultural land, agricultural production and food security are likely to be impacted by climate change, particularly in the vulnerable areas (HDRO, 2007; Ngaira; 2007). Some studies have confirmed that climate change will have impacts on rain-fed agriculture, which is mostly practiced by subsistence farmers in Africa, as agricultural products are often affected (Adams *et al*., 1998; Crosson, 1997; Pant, 2009).

It is a common tragedy in developing countries that poor communities are more vulnerable to climate change than other segments of the population. While climate change affects everyone, it disproportionately affects the poor (Agerup *et al*., 2004). In the view of floods, which can be associated with climate change and variability, poor communities are said to be more vulnerable (McGuigan *et al*., 2002). Such disasters leave them less secure (HDRO, 2007; Hiyalwa, 2009; Simiyasa, 2009). This is due to the fact that many poor communities depend on agriculture for subsistence, however

agricultural resources are said to be vulnerable to floods. Vulnerability of agriculture to floods is mainly due to the fact that some poor communities tend to settle on low-lying areas/flood plains where there is fertile agricultural land (McGuigan *et al*., 2002). In addition, extreme floods usually cover extensive areas, including large areas of agricultural land. Generally, climate disasters are said to have significant impacts on long-term opportunities for human development. It has however been documented that the impacts of extreme weather events such as heavy rainfall and extreme floods are not necessarily a proof of climate change, but rather a proof of vulnerability to climate change, as climate change can increase exposure to climatic events (HDRO, 2007; Huq *et al*., 2007).

Given the extreme climatic events, poor communities are left with challenges of adapting to, and coping with climate change (McGuigan *et al*., 2002). As a consequence, many people fall into states of not being able to support themselves and experience hunger as well as many survival difficulties. Predictions have shown that up to 250 million people in Africa could be exposed to the impacts of climate change by 2020 (IPPC, 2007). Impacts include: water stress, increased floods and increased frequency of tropical cyclones. It has also been predicted that the agricultural sector is likely to experience periods of prolonged droughts and/or floods during the El Ninõ events (FAO, 2009). According to the predictions, variation in temperature and precipitation in Africa will result in increases in crop pests, diseases and soil fertility. In the absence of adaptation strategies for agriculture in Africa, agricultural development will remain threatened by climate change. It is therefore essential that adaptation measures should to be in place, especially in the most vulnerable countries. In Namibia specifically, poor communities have experienced heavy floods in 2008 and 2009, which led to the need of assessing the impacts of such floods on agriculture. The experienced heavy floods in northern Namibia also led to the need to identify the coping and adaptation strategies that are currently in place. With such knowledge, capacities to respond to longer term changes in local climate can be strengthened (Hulme *et al*., 2000).

This chapter sheds some light on the nature and extent of climate change in Africa, vulnerability to floods, impacts of floods on agriculture and livelihoods, as well as on the coping and adaptation strategies for floods. It has also paid a particular attention to the Namibian situation.

2.2. Impacts of climate change on developing countries

In general, developing countries are more vulnerable to climate change, which is where most poor people are found. It has therefore become an acceptable reality that the world's poor will suffer the consequences of climate change impacts (HDRO, 2007; Laukkonen *et al*., 2008). This is due to their vulnerability and the fact that they have limited human, institutional and financial capacities to respond to the effects of climate change (Sperling, 2003). As a result of the changing climate, poor people get exposed to disasters such as droughts, floods, intense storms and may face environmental stress, as they become less able to live better lives; further making them feel insecure (HDRO, 2007). Some of the experienced disasters are termed as climate shocks, which significantly affect long-term opportunities for human development. Nevertheless, climate shocks are also experienced in the richest countries, where events such as heavy rainstorms, cyclones, hurricanes, El Niño, and tsunamis occur (Huq *et al*., 2007).

Climate change can have adverse impacts in such a way that human lose development opportunities that are unlikely to be reversed (HDRO, 2007). Impacts on such opportunities include: affected agricultural production and food security; water stress and water insecurity; raising sea-levels and exposure to climate disasters; changes in ecosystems and biodiversity; affected human health; affected energy consumption and affected livelihoods (HDRO, 2007; Schipper & Pelling, 2006; Thompson *et al*., 2006; Tol, 2002). All impacted areas generally interact with the social, economic and ecological processes that shape opportunities for human development, as they do not operate in isolation.

Looking in depth at the specific impacts of climate change in developing countries in terms of agriculture, adverse impacts have been experienced. Drought in particular

affects agricultural productivity. As a result, food security is impacted, which can cause malnutrition among children that are born during drought, and may cause pre-mature deaths (HDRO, 2007; Kasperson & Kaperson, 2001; McGuian *et al*., 2002). Droughts can also cause reduction of income, as agricultural products that are harvested for selling purposes can be greatly affected. In the case of floods, cities and rural areas get affected, to the point that people have to leave their homes (Mirza, 2003; Huq *et al*., 2007). This has been experienced in African countries such as Ruanda, Burundi, Tanzania, Uganda and Mozambique.

In the view of warmer temperatures, risks of floods and droughts are increasing. These events increase heat stress in livestock and wildlife and can increase the risk of crop damage (Huq *et al*., 2006; Huq *et al*., 2007; IPPC, 2007; Kaperson & Kaperson, 2001; Kundzewicz *et al*., 2007; McGuian *et al*., 2002). A study conducted in Namibia has predicted that increasing atmospheric temperatures are likely to cause loss of plant species in the northern and central parts of Namibia (Midgley *et al*., 2005).

It is also worthwhile noting that climate change can have impacts on the economy. Exposure of economic sectors such as agriculture, fisheries and tourism to climate change can therefore have an adverse effect on the economic growth (McGuian *et al*., 2002). Furthermore, climate change can have adverse impacts on poverty, particularly because poor people almost entirely depend on natural resources, which are vulnerable to the impacts of climate change (Adger *et al*., 2003; Sperling, 2003).

In terms of agriculture, there is enough evidence to prove that African agriculture is vulnerable to climate change (Desanker, undated; Maddison *et al*., 2007; Mendelsohn *et al*., 2000). A study conducted by Ngaira (2007) has revealed that Africa is already experiencing devastating impacts of climate change; mainly observed in the events of floods and drought; resulting in shifts in marginal agricultural systems. Vulnerability of African agriculture is attributed to the fact that most of Africa relies on rain-fed agriculture, which is vulnerable to changes in climate variability, seasonal shifts and precipitation patterns (Desanker, undated). Based on the predictions, an increase in

temperature of between 1.5º C and 4.5ºC is expected by 2030, and this will adversely affect the agricultural systems in Africa, particularly food security (Ngaira, 2007). It is worthwhile to note that climate change affects both crop and livestock production practices and yields (Pant, 2009). With respect to agricultural productivity, several categories are impacted by changes in temperature, precipitation, atmospheric carbon dioxide content, the incidence of extreme events and sea level rise (McCarl *et al*., 2001). More details of the impacts are presented in Table 1 below.

Table 1. Impacts of climate change on various categories of agricultural practices that influence agricultural production

CATEGORY	IMPACT
Crops and forage productivity and production cost	Temperature, precipitation, atmospheric carbon dioxide content and extreme events are likely to alter plant growth and harvestable yield. These parameters also impact the plant water demand. Extreme and frequent events of droughts and floods result in an increase agricultural losses.
Soil suitability for agricultural production	Available soil moisture for plant growth, moisture storage capacity and fertility are affected. Soil moisture loss is determined by temperature and maintenance of a constant water supply. Warmer temperatures stimulate microbial decomposition, which negatively affect the soil nutrients and soil moisture which help to hold the soil moisture.
Livestock productivity and production cost	Livestock productivity and production cost are affected by a change in balance between heat dissipation and heat production. Animal mortality, feed conversion rates, rates of gain, milk production, conception rates and appetites are altered by the change in the balance. Availability of feed and fodder is known to affect the carrying capacity.
Irrigation water supply	Changes in the volume of water supplied by precipitation affect irrigation water supply. Increases in temperature also affect evaporation, groundwater recharges rates and hydrological cycles; and hence the available water.
Other effects	Agricultural production can be indirectly impacted by climate change. Examples of indirect effects are: alternations in the growth rates and distribution of weeds, pests and pathogens, rates of soil erosion and degradation. These may result from sea level rise, which can inundate the low-lying coastal regions.

Adapted from McCarl *et al*., (2001)

Other effects of climate change on African agriculture include: reduced agricultural land-use due to submergence of coastal regions, increased aridity in the tropical areas, increased incidences of farm pests and diseases, over cultivation, and poverty (Ngaira, 2007). According to Maddison *et al*. (2007), changes in temperature and precipitation are likely to have significant effects on run-off; therefore the effects of climate change may be severely felt through impacts on water supply. It should be noted that climate change has both positive and negative effects on agriculture. Nevertheless, negative effects are more prominent than the positive effects (Pant, 2009).

2.3. Climate patterns in Africa, with particular focus in Namibia

A study conducted by Hulme *et al*. (2000) has concluded that Africa has become warmer than it was over the past century. Notably, the warming rate has been observed to be at 0.5ºC per century, with warming slightly larger in the period of June to August and September to November compared to December to February and March to May. From the agricultural perspective, global warming will increase the potential evapo-transpiration rate, along with the increasing water demand (Feddema, 1999). Studies have revealed that since 1987, there have been six extremely warm years in Africa, of which 1998 was the warmest (Hulme *et al*., 2000).

Looking at the precipitation, it has been predicted that the extent of Inter-Tropical Convergence Zone (ITCZ) migration and intensity is likely to change as precipitation changes (Feddema, 1999). According to Hulme *et al*. (2000), inter-annual rainfall variability is large over most of Africa, however, with substantial multi decadal variability in rainfall in some regions, most notably the Sahel. Furthermore, predictions have shown a potential increase of 30 mm in precipitation across the continent. Such a change is expected over the tropical parts of the continent, particularly along the coastal equatorial regions, the southern Sahel Region, and the Guinea coast of west Africa where annual increases of 150 mm has been predicted. Moreover, Feddema indicated that the northern part of southern Africa is expected to get wetter, with average increases of 50 mm. Overall, the southern part of the continent has shown a drying of

50 mm (Feddema, 1999). With regard to interannual rainfall variability in Africa, the El Ninõ/Southern Oscillation is one of the most important factors for some regions (Hulme *et al*., 2000).

In general, Namibia is arid to semi-arid and has variable and unpredictable rainfall (Barnard, 1998). The pattern of the rainfall season is known to be consistent throughout the country while the actual amount received varies between years (Dirkx *et al*., 2008). Such a variation in rainfall has been observed between 1901 and 2000, both in northern and southern Namibia. Although it is difficult to measure trends in rainfall patterns, an increase in the rainfall intensity has been observed. Rainfall in Namibia normally starts in the northern part of the country, with January and February being the wettest months (IWRM, 2009). The rainfall received in north central Namibia ranges between 400mm and 600mm, however, a small portion in the north central region receives more than 600mm, as you move eastwards (Mendelsohn *et al*., 2000).

With due consideration of daily rainfall data that is recorded at various stations, it is possible to determine the climate patterns in Namibia. Drier climates are said to be more linked to the rainfall season due to the fact that rainfall is known to occur more during the so called “core months”, which can however be of either sufficient or insufficient value to productivity (Olziewski, 2010). According to Olziewski (2010), rainfall within the pilot sites for this study falls within the core months of December to March, and can be associated to other months prior and following the core months: November and April. More support to the reliability of rainfall in the study sites is given by the position in the wetter side of the semi-arid part and adjacent to the drier consideration of sub-humid. Research has shown that the rainfall season of 2007 was dominated by an ENSO event which collapsed in mid-season, but took some 54 weeks to correct the Oscillation factor. This caused a reduction in rainfall, making it moderate to poor. The rainfall season for 2008 is said to have showed an active ITCZ core over western Zambia during December, which apparently drifted west to southern Angola by end of January. As a result, the rainfall flooded the Cuvelai Delta, flowing all the way to Etosha pan, which overflowed. The same pattern was observed in 2009. The two

seasons can be associated with the Pacific Ocean La Nina events. In general, external influences on the climate within the pilot sites for this study are: Benguela El Ninõ, Pacific El Ninõ and the La Nina years. Records have shown that the semi-humid part of the study sites has more days of productive rainfall (10mm a day), followed by slightly reduced number of days with substantial rainfall (25 mm a day) and a few days of wet rainy spells (1 mm or more a day) and wet spells (60 mm rising by 20 mm a day). The same is experienced in the sub-humid part of the study sites (Olzewski, 2010).

In terms of temperature, increases in temperatures have been observed over the years, with maximum temperature exceeding 35ºC being experienced (Dirkx *et al*., 2008; IWRM, 2009). Predictions have shown that Namibia will become more hotter throughout the year, with an increase of between 1ºC and 3,5ºC in Summer and 1º to 4ºC in Winter for the period between 2046 and 2065 (Dirkx *et al*., 2008). Nevertheless, it should be noted that temperatures in Namibia are increasing (New *et al*., 2006).

2.4. Vulnerability to climate change

For the purpose of this thesis, vulnerability is defined as the ability to cope, adapt and recover from the impacts of climate change. Vulnerability is known to manifest itself in poorer countries due to lack of resources and capacity to respond to the changes in the environment (McGuigan *et al*., 2002). In Africa, vulnerability to climate change is more exacerbated by climate events such as droughts and floods, and some factors including the widespread of poverty and immediate daily dependence on natural resources (Simms, 2005). The impacts of floods include: destruction of crops and livestock, loss of houses, loss of infrastructure and loss of jobs. As a result, livelihoods are affected, especially because many African people depend on agriculture for survival.

It is generally accepted that poor people are proportionately more exposed to environmental hazards and environment-related conflicts than other economic sectors of the population (McGuigan *et al*., 2002). However, they have limited capacity to cope with natural disasters and conflicts. The same applies to the impacts of climate change.

Considering the fact that poor people are more vulnerable to climate change than other groups of people in any society, it is essential to enhance their adaptive capacities. However, developing long-term adaptation strategies requires a good understanding of people's vulnerabilities to climatic events (Mirza, 2003). In order to understand the vulnerabilities of communities to climatic events, vulnerability assessments are usually conducted (DFID, 2004). It therefore becomes necessary to identify the vulnerable groups and to assess their sensitivity and adaptation capacities (Schippers *et al*., 2008). In essence, vulnerability assessments aim at informing the development of policies that reduce the risks associated with climate change (Füssel & Klein, 2005). Furthermore, vulnerability assessments are performed to increase the scientific understanding of climate sensitive systems under the changing climate and to develop adaptation and mitigation measures aiming to reduce the risks of climate change.

Given the flood situation in Namibia experienced over the past two years as explained in the preceding section, an assessment was conducted, which helped to establish an understanding of the causes of severe floods. According to the Flood Emergency Management Coordination Office (FEMCO) report of 2009, heavy floods are associated with heavy rainfall, low lying levels of some regions in the Cuvelai Delta, inadequate storm water drainage systems in urban and rural areas, lack of proper maintenance programs on the existing storm water drainage systems, low capacity of bridges and culverts to disperse flooding water freely, blockage of storm water drainage systems by infrastructure development and settlement of people in the flood prone areas. Similarly, an assessment of vulnerability and adaptation to climate change was carried out in Namibia in 2008. This assessment has established an understanding that vulnerability to climate change in some areas can be determined by changes in rainfall intensity and lack of coping mechanisms (Dirkx *et al*., 2008). Through such an assessment, it was identified that high dependency on agriculture for livelihood is one of the causes for vulnerability. Other socio-economic factors such as poverty, unemployment, prolonged illnesses and deaths of bread winners in the family were also identified as contributing factors to vulnerability (Dirkx *et al*., 2008). Such factors also influence the adaptive capacities of individual households and communities. Furthermore, the levels of income

and poverty influence the resource base of households, which determines the resilience of households to deal with the impacts of climate change.

2.4.1. Impacts of floods on agriculture

The impacts of floods on agriculture have been widely researched on. According to Thompson & Penning-Rowsell (undated), agricultural loses occur even when floods are moderate. Floods may destroy crops that may be ready for harvest (ZVAC, 2009), may increase starvation (Armah *et al*., 2010), may influence land-use changes and increase the desire to migrate (Armah *et al*., 2010; Ongwenyi *et al*., 1993); and may have impacts on agricultural wages (Armah *et al*., 2010; Banerjee, 2005; Thompson & Penning-Rowsell, undated). It is evident that extreme floods can have impacts on agricultural production and food security (HDRO, 2007; Tol, 2002). In fact, agriculture is the major source of food security in many poor communities. Floods can affect agriculture by causing changes in soil fertility, by reducing crop yields or land productivity, by damaging and destroying crops, by increasing disease burdens, by declining household incomes, by destroying agricultural lands in which people depend for livelihoods as well as by impacting the development of water resources (ADAS, 2007; Armah *et al*., 2010; McGuigan *et al*., 2002; Mirza, 2003; Nunes *et al*., 2010; Tol, 2002). This has been observed in some African countries including Ghana, Kenya, Mozambique, Namibia, Zambia and Zimbabwe. Specifically in Mozambique, floods caused a loss of at least one third of maize production, which is the stable food, and loss of 80% of its cattle (WSWS, 2001 in Mirza, 2003). It also destroyed large proportions of crop lands. A similar situation was observed in 2006, when floods destroyed an estimate of 40,000 hectares of maize cropland in Mozambique (SADC, 2006). Cases of destroyed croplands were also reported in Angola and Malawi. According to McGuigan *et al*. (2002), farmers risk losing crops as the floods usually occur during the harvesting season. In Bangladesh, both positive and negative effects of floods on agriculture were identified. A study conducted by Banerjee (2005) revealed that floods can have a positive impact on agricultural wages in Bangladesh, and may also cause a decline in the districts that are inundated. Similarly, a study conducted in

Kenya revealed that floods control may release large areas of land (over 40,000 ha) for annual cultivation, which has positive influence in the agricultural income almost three times (Ongwenyi *et al.*, 1993). In Niger, flooding was experienced in 2009, which killed 3,650 livestock (USAID, 2006).

The flood disaster experienced in Namibia in 2008 impacted agriculture in such a way that 63,637 livestock were lost, while 150,000 hectares of agricultural land was destroyed (OPM, 2008). In fact, floods can cause inundation of agricultural lands. During the floods experienced in 2009, grazing lands in some parts of Ohangwena Region were inundated by water, and large numbers of livestock (i.e. cattle, sheep, donkeys and goats) were lost due to floods (FEMCO, 2009; Hiyalwa, 2009). It was reported that a total of 1656 farmers in Ohangwena Region lost their grain baskets (grain storages), while a total of 5671 farmers' crop fields were totally destroyed by floods that were experienced in 2009 (FEMCO, 2009). In total; 10,117 hectares of crop fields were destroyed in Ohangwena Region during that period. Such a disaster left approximately 22,544 people in Ohangwena Region in critical need of food relief.

2.4.2. General impacts of floods on human development

Climate change can have influence in the flooding risks. Sea level rise, glacial outburst and heavy or prolonged rainfall can cause flooding (Huq *et al*., 2007). Increased risks of flooding can have severe impacts on both urban and rural areas. Floods can impact infrastructure, human health, economic growth and can cause deaths (Huq *et al*., 2007; Karuaihe *et al*., 2008; Mirza, 2003). Furthermore, floods can negatively impact poverty. This is due to the fact that poor people often live in flood prone areas; therefore their poverty limits their ability to cope with and to recover from the flood events. Additionally, poor people often live in areas lacking the infrastructure of Early Warning Systems (EWS), which help people to cope with disasters (McGuigan *et al.*, 2002). Floods may decrease the overall environmental quality and may force people to migrate. Events of floods in Africa have caused thousands of people to leave their homes in Mozambique in 2000, in Rwanda, Kenya, Burundi, Tanzania and Uganda in 2002, in Ethiopia in 2006

and in Namibia in 2008, 2009 and 2010 (Huq *et al*., 2007; FEMCO, 2008, Nunes *et al*., 2010). However, moving people from one area to another can be costly (Ongwenyi *et al*., 1993).

During the 2005/2006 rainfall season, heavy rainfall was experienced in southern Africa and resulted in flood (SADC, 2006). In December 2005, heavy rain fell in southern Malawi, central and southern Mozambique, north eastern Namibia (Caprivi Strip), northern Botswana, northern South Africa and southern Angola, which resulted in floods. These events of floods were quite catastrophic. In Mozambique, many death cases were noted, while hundreds of families (approx. 1800) were left homeless. These floods left the city of Inhambane in isolation particularly because the road to the city was damaged. The worst is that, despite the damage, the country was not in an emergency situation. In Namibia, Windhoek specifically, over 40 houses were flooded after the rainfall that fell in January 2006 (SADC, 2006).

Heavy seasonal rains and associated floods killed more than 180 people and affected more than 600,000 people in West Africa in June 2009 (USAID, 2009). The following countries were affected: Burkina Faso, Mauritania, Niger and Senegal (affected populations of 150,000; 9,000; 79,129 and 264,000 respectively). Increases in malaria and diarrhea cases were noted, while thousands of people had to leave their homes. In Burkina Faso, the central hospital was partially closed due to floods. In addition, a generator in the city water plant was also destroyed (USAID, 2009). In Niger, flooding destroyed 3 people's lives and adversely impacted roads, schools, wells and agricultural land.

An event of flood was also experienced in southern China in June 2010. In this flood event, deaths of approximately 380 people were recorded, as well as an economic loss of US$12.3 billion (Rasmussen & Staff, 2010). Further to these, 11.1 million acres of total cropland was damaged, while livestock losses were also experienced. Floods in China impacted vegetable transport, which decreased the local food supply. However, this impact contributed to increased vegetable prices (Rasmussen & Staff, 2010). Such

a situation challenges the food security, especially for those who cannot afford expensive food.

During the heavy floods experienced in Namibia between 2008 and 2009, many people in the northern part of the country were forced to leave their homes, moving to higher grounds (Hiyalwa, 2009; OPM, 2008). In the event of floods experienced in 2008, over 200,000 people were affected (OPM, 2008). In addition, 32,050 learners from 100 schools were affected. There were also 100 human death cases that were related to the floods. The flood disaster of 2009 caused more than 1000 people to be relocated from their houses during the peak period, while approximately 205 households were relocated (FEMCO, 2009).

In the events of extreme floods, public institutions have to be closed down. Such a situation was experienced in many countries including Kenya, Mozambique, Namibia and Zambia (ZVAC, 2009; FEMCO, 2009, Huq *et al.*, 2007; Ongwenyi *et al*., 1993). In Namibia, Ohangwena Region specifically, it was estimated that 387 small and medium enterprises were closed due to floods in 2009 (FEMCO, 2009). These are, however, the sources of people's incomes, which contribute to their livelihoods. Nevertheless, it is worthwhile to note that the frequency and magnitude of floods are expected to increase due to climate change, along with the vulnerability of the developing countries (Mirza, 2003).

2.5. Conclusion

The African continent is vulnerable to climate change and is at risk of climate change impacts. Changes in rainfall patterns and temperature are some of the notable signs of climate change. Generally, changes in such parameters have impacts on agriculture and can affect food security. Subsistence farmers are at risk of climate change impacts, as they mostly depend on rain-fed agriculture. Africans, mostly poor communities are vulnerable to climate change, given the fact that they lack resources to support themselves. Vulnerability assessments are thus conducted to determine their adaptive capacities. Such assessments help to develop mitigation and adaptation measures.

Communities in developing countries, including Namibia are in dire need of adaptation strategies for floods, especially due to the many experienced events of floods. Such communities therefore suffer the consequences of floods, particularly in terms of agriculture, on which they almost entirely depend for subsistence.

CHAPTER 3: ADAPTATION AND COPING STRATEGIES FOR CLIMATE CHANGE

3.1. Introduction

Extensive literature has acknowledged that climate change is increasingly affecting the poor. With this in mind, developing coping and adaptation strategies for climate change should be placed as a priority. Such strategies need to be in place to ensure survival and sustainable development (Sperling, 2003). Adaptation and coping strategies are usually concerned with human development, since the factors that are impacted by climate change are related to human development. It is therefore worth-noting that there is a close link between adaptation and development, which is critical to reducing vulnerability to climate change (Schipper *et al*., 2008).

Coping strategies are usually developed at the local level, and are mainly designed to respond to the short-term impacts of climate change. With the ever changing climate, it is essential that there should be adaptation strategies in place, for responding to the long-term impacts. Adaptation measures need to be developed in collaboration with scientists and practitioners, who should aim to enhance local adaptation capacity (Ziervogel *et al*., 2008). Nevertheless, these can only be developed once the coping strategies are known (Dirkx *et al*., 2008).

So far there is no clear definition as to what adaptation really means. However, various scientists and researchers have come up with different definitions, to fit within the context of the environments that they focus on. In general, adaptation involves a process of sustainable and permanent adjustment in response to new and changing environmental circumstances (Schipper *et al*., 2008). It involves creating stronger linkages between communities, placing efforts on sharing of lessons from one another, based on experiences. In the view of climate change, adaptation mainly aims at addressing the adverse of actions towards vulnerability (Füssel & Klein, 2005). Additionally, developing adaptation strategies for climate change requires knowledge of

the best available scientific information, including climate data (Dirkx *et al*., 2008; Füssel & Klein, 2005; Schipper *et al*., 2008; Ziervogel *et al*., 2008).

In this chapter, a highlight is given on adaptation and coping strategies for climate change. Emphasis is placed on the adaptation strategies for reducing vulnerability to climate change, in general and particularly in the view of the floods recently experienced in Namibia.

3.2. Adaptation for climate change

Due to the fact that poor countries are the most vulnerable to climate change, it is advisable to start with poverty reduction when addressing the climate change impacts (Ågerup *et al*., 2004). Poverty reduction may involve promotion of economic growth (Laukkonen *et al*., 2008). In addition, responding to experienced or expected climatic conditions requires the affected countries/areas to make some adjustments in behavior, livelihoods, infrastructure, laws and policies and institutions (Schipper *et al*., 2008). Responding to climate change also requires communities to be willing to change and to access appropriate technologies for adaptation (Tompkins & Adger, 2005). While adaptation is necessary, it can only succeed if it is both reducing the vulnerability of the poor people to existing climate variability, and aiming at addressing future impacts (Sperling, 2003).

The critical impacts of climate change in the most vulnerable countries were recognized at the 15th Conference of Parties on the United Nations Framework Convention on Climate Change (UNFCCC) in December 2009 (United Nations, 2009). This has led to the need to establish a comprehensive adaptation program, which will include international support. It is essential to develop adaptation measures, as they will reduce vulnerability and build resilience in the developing countries, particularly in the most vulnerable countries, among which African countries are included.

In general, adaptation strategies include mainstreaming climate change issues into economic planning and budget process, increasing the resilience of infrastructure and investments, enhancing the financial resilience of the poor, improving governance through mainstreaming climate change issues in poverty reduction, mainstreaming adaptation into sustainable development, engagement with the UNFCCC process, integrated water resource management, public education, flood management, nature conservation, common property resource management and sourcing of funds (Sperling, 2003; Tompkins & Adger, 2003; Tompkins & Adger, 2005).

3.3. Adaptation and coping mechanisms in agriculture in the face of a changing climate

With the notion that climate change will have long-term impacts on agriculture, it is almost obvious that many farmers will remain vulnerable to the widespread effects of climate change (FAO, 2009). Therefore enhancing the farmers' adaptive capacity should be placed as a priority. Development of adaptive capacity in agriculture brings together stakeholders from various disciplines including climate scientists, agricultural practitioners and technicians, local communities, donors and policy makers (Ziervogel *et al*., 2008). This is due to the fact that it requires proper planning for different adaptation strategies, which will help addressing different conditions (Schipper *et al*., 2008).

At the local level, communities implement coping strategies such as: making use of traditional knowledge, precautionary storage of food, producing crops that could raise income, make use of drought resistant crops, selling of assets and cutting on meals (HDRO, 2007; Schipper *et al*., 2008). In many African countries, farmers switch crops to adapt to climate change. Some farmers practice cultivating maize-millet, maize-sorghum and maize-groundnut in the cooler regions of Africa; while those in moderately warm regions maize; those in hot regions grow millet-groundnut; whereas those in dry conditions grow cowpea, cowpea-sorghum and millet-groundnut (Kurukulasiriya & Mendelsohn, 2006). The farmers base their choices of crops on the climatic conditions. In northern Namibia, communities practice cultivating the mahangu crop (millet),

because it is relatively drought resistant and can take root again after dry periods (NPC, 2004).

In terms of floods, various actions need to be taken to reduce the risks involved. These include: provision of infrastructure, disaster preparedness (including early warning systems, taking measures to limit damage, moving people to safer areas quickly) and through disaster responses, which include providing rescue services and appropriate emergency services (Huq *et al*., 2007).

A study conducted in northern Ghana grouped coping strategies in three categories: "immediate", "short-term" and "long-term" (Armah *et al*., 2010). The immediate strategies refer to those strategies undertaken during and in the immediate consequence of the floods. Short-term strategies refer to those strategies implemented in a period less than one month after the floods have occurred, while the long-term strategies are implemented over a period more than one month after the floods. The example of coping strategies implemented in Ghana are: roofing of thatch houses for money, fishing, weeding the farms of others in return for food, trading and selling in nearby townships, obtaining loans from social contacts, selling of livestock, pre-mature harvesting of crops, weaving and basketry, dependence on food from previous crop seasons and resettlement in other towns. In a flood impact assessment conducted in Zambia, some of the coping strategies for floods that were identified were: collection of wild fruits, using roots and grasses for food and selling, collection of water lilies's roods, collection of reeds for mat making, and also selling of local chickens (ZVAC, 2009). In the case of floods in Namibia, the affected people are moved to higher grounds and provided with emergency tents and emergency food aid (Hiyalwa, 2009; OPM, 2008).

Due to the heavy floods experienced in West Africa in June 2009, emergency relief was provided (USAID, 2009). In Burkina Faso, the affected people were moved to schools, churches, mosques and to host families. Financial contribution of over a million US$ was also donated in support for provision of temporary shelters, interventions in agriculture, food security and economic recovery and market systems. Food assistance

was also provided (USAID, 2009). In Mauritania, those people that were affected were relocated to camps and were provided with medical assistance as well as emergency relief supplies (food, potable water and tents). Emergency response was also provided to those who were affected in Niger. They were provided with US$ 50,000 through the U.S. Embassy for cash activities to rehabilitate basic infrastructure and to carry out activities in the impacted areas. The same amount was also provided in Senegal for the same purpose (USAID, 2009). Food assistance was also provided in Niger. In Mauritania, USAID/OFDA provided approximately US$25,000 for the purchase and installation of latrines in the temporary camps and other hygiene supplies. USAID/OFDA also provided another amount of US$30,000 to Mauritania by for relief commodities.

3.4. Identifying adaptation options to increase adaptive capacities

Identifying adaptation options requires making use of different sources including: scientific and technical information, countries experiences, local expertise, coping strategies and traditional knowledge (Schipper *et al*., 2008). Such information helps to determine what will work and what will not work at the target level e.g. household, community or state level. The following factors have been identified as having influence on adaptive capacities: economic resources, technology, infrastructure, information and skills, institutions, equity and macro-level policies (DFID, 2004; Vogel & Reid, 2005). These are known as the determinants of adaptive capacity, and can enhance capacity if correctly implemented. In addition, capacity to modify social behavior and social environment and the perceived vulnerability to climate impacts will influence the preference for a more technological response to the changing environment (Tompkins & Adger, 2005). Furthermore, natural disasters such as floods are known to increase societal vulnerabilities to climate change; therefore they need to be reduced, in order to increase human adaptive capacities (Yohe *et al*., 2007). This can be made possible through developing and application strategies aiming to minimize vulnerabilities and impacts of disasters through combination of measures for reducing physical hazards and enhancing social and economic capacities to adapt to the changing environments.

It is worthwhile to note that the quality of the government has influence on the level of risk from climate change faced by those with limited incomes or assets (Huq *et al*., 2007). This is due to the fact that the government has significant influence on the provision of infrastructure, disaster preparedness (e.g. early warning systems) and disaster response (e.g. rescue services, emergency and rescue services). Therefore it is important that governments should have an understanding of the vulnerabilities of the impacted societies, and of the hazards associated with the disasters in order to be able to estimate the risks and impacts; and to ultimately reduce the risks involved (DFID, 2004). In such a way, adaptive capacities can be influenced.

A workshop on flood disaster lessons learned in Namibia was held in 2008, at which recommendations for improved flood preparedness and response mechanisms were made (OPM, 2008). The recommendations include: preparedness planning activities (which include budgeting for preparedness, epidemic surveillance system of modifiable diseases and infrastructure development); early warning activities (including establishment of an early warning system, increasing the number of flood monitoring stations and establishment of information sharing between Namibia and Angola); response activities (including development and implementation of a criterion for identifying people's needs, involving communities in developing responses to disasters and strengthened coordination with traditional leaders), coordination activities (such as establishment of national structures, identification and verification of affected people, putting in place a uniform information communication and technology infrastructure and coordination of meetings), recovery activities (such as management of transition from disaster response to livelihoods recovery and provision of psychological support to disaster victims) and logistics activities (including facilitation of custom clearance and arrangements for international partners, development of a relief distribution plan and mobilization of dedicated emergency warehouses). These measures need to be implemented in order to reduce both current and future vulnerabilities, and to increase the adaptive capacities for the vulnerable communities in northern Namibia. Noteworthy, incorporating climate change and its uncertainty into vulnerability reduction measures is essential in order to ensure that they are truly sustainable (Yohe *et al*., 2007).

3.5. Conclusion

Adaptation strategies need to be in place to address the impacts of climate change. They play a significant role in reducing vulnerability. Adaptation strategies can only be developed for local communities once the coping strategies are known. Developing strategies requires some knowledge of climate data, and collaboration with experts from various (relevant) disciplines. Although there is no clear definition of adaptation, it is almost clear that it aims to respond to changing environments. Poor countries are in dire need of adaptation strategies, however, they should be willing to respond to appropriate technologies for adaptation. The vulnerability of the poor people needs to be considered when planning for adaptation. The international recognition of the need to develop an adaptation programme for the most vulnerable countries is duly acknowledged, particularly because vulnerable countries lack resources to support themselves. In terms of agriculture, farmers in Africa are already making use of some coping and adaptation strategies; however, they need further support, particularly when the situations get out of their control. Specifically for Namibia, farmers need to have adaptation strategies for floods, especially after the recent events experienced over the past two years, and the fact that more flood events are likely to occur in future. In essence, their adaptive capacities need to be enhanced in order for them to be able to survive during future flood disasters.

CHAPTER 4: METHODOLOGY

4.1. Summary of the Research Methodology

The methodology used for this research is described in this chapter under the following sections: research design, research site, target population, sampling technique, sampling size, data collection, data capturing and data analysis. A highlight has also been given on the limitations to this study. The research was conducted in four selected constituencies, whose selection a criterion is highlighted in one of the sections below.

The research methodology employed by this study was participatory, as it involved community consultations. Various meetings were held with farmers from the selected constituencies through the focus group discussion approach, in order to collect in-depth qualitative data about the communities' experiences on climate related issues in relation to agriculture. As part of the focus group discussions, the Participatory Rural Appraisal (PRA) technique was used, a data collection technique that involves outsiders (e.g. professionals from different sectors and disciplines) and communities to collect data from communities in such a way that outsiders facilitate communities to share and analyse information in order to plan and act (Bhandari, 2003). The PRA technique was chosen for the fact that it promotes participation, particularly because it involves participation-based activities such as diagramming and discussions through semi-structured interviews. Such an approach helped the researcher to develop a better understanding of how farmers in Ohangwena Region, are impacted by, and cope with the climatic events i.e. floods and drought. In essence, understanding the coping mechanisms helps researchers to develop future adaptation strategies (Dirkx *et al*., 2008).

Further to the data collected through consultation with farmers, the researcher conducted a literature review in order to get an insight from other researchers on related issues, for comparison. The information provided by farmers helped the researcher to

critically analyse the impacts of climate variability and change on agricultural practices, as well as to identify the coping strategies currently in place within the Ohangwena Region.

Based on the focus group discussions held; possible future adaptation strategies were proposed and agreed upon with the communities. These were proposed based on the analysis of the coping strategies currently in place. Adaptation strategies are needed due to the fact that coping strategies are mainly short-term and immediate responses to climatic disasters; however, they are not sustainable (Dirkx *et al*., 2008). Having adaptation strategies in place will enhance the communities' adaptive capacities.

4.2. Research Design

Achieving the research objectives required the researcher to employ mixed research methods, particularly because different approaches were needed in this research in order to get the desired results. The research therefore employed both qualitative and quantitative designs, as it aimed to collect both textual and numerical data. This study was exploratory, as it intended to gain an in-depth insight of how the farmers in Ohangwena Region are affected by, and cope with climate change (Mouton, 2001; Maree, 2007). Understanding how communities in the region cope with the impacts of floods was therefore made possible by obtaining rich and textual qualitative data. However, numerical data were also necessary for the purpose of quantification (Maree, 2007). The number of people who participated in this research was recorded, which served as the numerical data. Such data was necessary to quantify the proportion of the population that has contributed to the textual data out of the target population. A descriptive survey design was employed in this research, as it helped the researcher to obtain information from a sample population, which could be generalized to a larger population (Maree, 2007). The research was purely empirical, as it aimed to collect primary data, i.e. data that did not exist before (Mouton, 2001).

4.3. Research Site

Ohangwena Region (10,703 km^2) is one of Namibia's 13 geographical regions that is located in north-central Namibia, bordering the Kavango Region to the east, Omusati Region to the west, Oshana and Oshikoto Regions to the south and Angola to the north (LAC, 2004). It is divided into 11 constituencies, namely: Ohangwena, Epembe, Endola, Ondobe, Okongo, Oshikango, Engela, Omulonga, Eenhana, Omundaungilo and Ongenga. Ideally the research would have covered all 11 constituencies in the Ohangwena Region; however, the available resources and time constraints could not allow such wide coverage. It is therefore for these reasons that four constituencies were selected as focal areas for this research. They served as pilot sites for the study, after which the outcome of the study will be replicated in other constituencies within the region. The lessons learned from the focal research areas were documented, which contributed to the recommendations on the future adaptation strategies for climate variability. Such recommendations will need to be implemented in the pilot sites, and if effective, they can be shared with other constituencies within the Ohangwena Region. The four pilot sites for the study were: Endola Constituency, Ondobe Constituency, Ongenga Constituency and Eenhana Constituency (Figure 2).

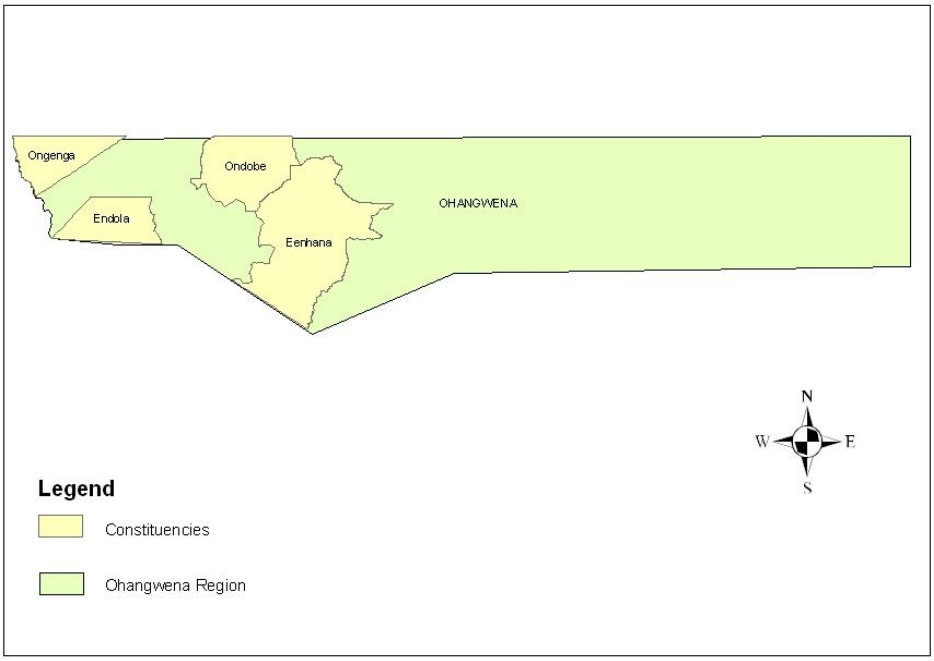

Figure 2. Map of Ohangwena Region showing Ongenga, Endola, Ondobe and Eenhana Constituencies

In order to collect information from the selected constituencies, the researcher wrote a letter to the Ohangwena Regional Governor requesting permission to contact research in the region. In addition, separate letters were written to the Regional Councillors for the four respective constituencies, informing them about the research, while at the same time inviting them to the focus group meetings and requesting them to nominate and invite 25 farmers to the meetings. Two separate meetings were held with farmers in the four focal constituencies for this study. More details on the two meetings are presented in Section 4.7.

The Ohangwena Region falls under two major landscapes: Cuvelai and Eastern Kalahari Woodlands. The Cuvelai landscape covers about a third of Ohangwena Region

on the west, while the Eastern Kalahari Woodlands biome dominates most of the central and north-eastern parts of Ohangwena Region (NPC, 2004).

4.3.1. Cuvelai

Cuvelai is a drainage system that is situated in the northern central Namibia, located between the Kunene and Kavango Rivers (Mendelsohn *et al*., 2000). It is characterized by highly variable water resources, which are usually arid between May and October, and get flooded between January and April (Cuvewaters, 2008). The Cuvelai system supports approximately 45% of Namibia's population that mainly depends on agriculture and fishing. This system forms a delta that drains water from southern Angola into the country, and floods the drainage channels during good rainy seasons (Mthoko *et al.,* 1990). As a result, the flood prone areas are threatened. Ohangwena is among the four regions (Omusati, Ohangwena, Oshana and Oshikoto) in northern Namibia that are vulnerable to floods, which result from this drainage system (DREF, 2009). During heavy rains, the water levels in the four regions tend to rise, which impacts infrastructure and agriculture. Two focal areas for this study; Endola and Ongenga constituencies are located in the Cuvelai landscape.

4.3.2. Eastern Kalahari Woodlands

The Eastern Kalahari Woodlands landscape is dominated by Kalahari sands, large trees and deep rooted shrubs (Mendelsohn *et al*., 2000). It is characterized by scattered clay pans and a few drainage lines. This landscape is made up of the following vegetation types: *Burkea-Baikiaea* woodlands, *Burkea-Terminalia sericea* shrublands, *Burkea-Combretum* savanna, Dense *Baikiea* woodlands, Mixed *Acacia* Kalahari woodlands, North-eastern pans, Omuramba drainage and *Terminalia prunioides-T.sericea* wood and shrublands. The Ondobe and Eenhana constituencies are located in the Eastern Kalahari Woodlands landscape.

4.4. Target Population

The researcher worked closely with the regional leaders, farmers and some relevant stakeholders in order to collect necessary data for this research. In this research, farmers refer to those people who own agricultural lands, and practice farming, both males and females. They are the people who have some experience on how farms are impacted by, and cope with changes in the climate. It was necessary to involve the regional leaders, as they are usually well informed of what is happening in the region in terms of climate change events e.g. floods. For this reason, the councilors were asked to be part of the meetings held with the farmers within their respective constituencies.

4.5. Sampling Design

This research considered using the purposive sampling design to select the research participants. Purposive sampling refers to the selection that is made according to a pre-selected criterion relevant to the research questions (Maree, 2007). The research participants were purposely chosen based on their knowledge on the impacts of floods on agriculture, the coping strategies, as well as current adaptation needs. The stratified sampling method has been used to select the pilot sites. This is due to the fact that Ohangwena Region is made up of 11 different constituencies, which for the purpose of this research referred to as strata. Of the 11 strata, 4 were selected to represent the target population, particularly because all the constituencies within the Ohangwena Region have more or less equal chances of being impacted by floods, given the geographical locations which they share. The four constituencies were selected based on their geographical locations, as well as on accessibility. Due to the fact that Ohangwena Region lies in two major landscapes, it was deemed necessary to select the pilot sites from the two different landscapes, as this would provide an opportunity to compare how communities in different geographical locations (Cuvelai and Eastern Kalahari Woodlands) are impacted by, and cope with impacts of floods. In addition, it is assumed that the two landscapes may respond differently to the experienced climatic conditions, given the fact that they are made up of different geographical features.

4.6. Sampling size

The number of research participants from the four selected sites slightly varied. The researcher requested the Regional Councillors to invite at least 25 farmers to the meetings; however, they only invited the maximum number that they could get hold of. The number of participants at each of the meetings per constituency is presented in Table 2.

Table 2. Number of participants at the consultation meetings held in the four study sites

Constituency	Number of participants	
	First meeting	Second meeting
Endola	25	21
Ongenga	15	11
Ondobe	15	14
Eenhana	20	19

The participants at the meetings were a combination on men and women who are in possession of farms/agricultural lands. No information on their age or educational status was revealed.

4.7. Data Collection Strategy

For the purpose of collecting data necessary for this research, the researcher used the focus group method. It is a method in which the moderator keeps a small group of people to discuss the research topic (Maree, 2007). Focus group discussion sessions were held in each of the four selected communities, during which situational analyses was performed. The discussion sessions were held twice in each constituency, with the key informants (local leaders and the farmers). Farmers from each constituency were selected by the councilors for the respective constituencies in which the research was conducted. Discussions and semi-structured interviews were held with the research

participants within the focus groups. A set of semi-structured questions was prepared in order to guide the discussions and to ease the participation by the farmers. Such questions were posed to the groups by a facilitator, in order to encourage interaction among the participants. The aim of the focus group discussion sessions was to collect relevant information from farmers in order to document the impacts of the recently experienced floods, vulnerability of communities to floods, the effectiveness of the coping strategies that are implemented when floods occur and the lessons learned from the four selected constituencies. The first set meetings aimed to introduce the farmers to the climate change concept in order to create awareness among the farmers of its existence. Such meetings also aimed to discuss the impacts of climate variability and climate change observed in the region, as well as the coping strategies in place. The questions that were asked to the farmers during the first meeting are attached as Annex. 1. The responses to the question helped the researcher to answer the research questions.

The second set of meetings involved PRA exercises. At these meetings, information was collected from community representatives using four PRA tools, namely: **Seasonal Calendar**, **List of Natural Products**, **Root Cause Analysis** and **Finding Solutions**. During the PRA exercises, necessary information was presented to the participants in order for them to understand what was expected from them. Understanding of the subject by participants helps them to apply their knowledge (Bhandari, 2003). This method of data collection is useful particularly because it limits unnecessary details and irrelevant data. It is a method of talking to community members in an interactive manner. In this technique, information is owned and shared by local people. Outsiders only facilitate the local people for the purpose of collection, presentation and analysis of information by themselves.

The seasonal calendar tool is used to document regular cycles such as seasons and activities that occur during a year; that may have influence in the life of a community (IECN, 2008). In this study, the seasonal calendar tool allowed the farmers in the four constituencies to present their local knowledge of the seasons during which various

agricultural related activities occur. Such a tool was used to collect information on the periods during which rainfall occurs, when cultivation is done, when harvesting is done, the periods when water is in oshanas and the dry seasons throughout the year. Based on community people's observations, useful information on seasonal cycles for the years 1994/1995 and 2008/2009 was collected. Information collection was made easy by drawing a circle marked with the 12 months of the calendar, presented in a clock manner, starting from January to December. Within this circle, different sized inner circles were drawn. These circles made it possible for different annual activities to be linked to different timelines.

The List of Natural Resources tool was used to obtain information on the types of natural resources that communities utilize apart from the agricultural products. It is a quick method of obtaining information on the types of plants and animals that are found within the community's boundaries and their common uses (IECN, 2008).

Through the Root Cause Analysis tool, the participants were able to identify the problems that they experience as a result of climatic events of droughts and floods. It is a useful tool that can be used to identify the causes of problems and their effects. This helps to determine whether climate change is the dominant factor. The participants were asked to come up with lists of problems currently faced by their respective communities, which they think are related to agricultural activities. All identified problems were listed. Out of the listed problems, those problems considered severe were identified and critically analysed to get an idea of their causes and effects. This was made possible by drawing a tree, referred to as a 'problem tree', whereby the major problem was marked within the trunk of the tree. The facilitator explained to the participants by telling them to assume that the tree was sick, and that there should be a problem that needes to be investigated. A further explanation was given that there are problems in the roots though which it feeds, therefore it was necessary to follow the problem back to the roots in order to understand why the tree was sick.

The facilitator asked the participants to brainstorm over the possible causes of the problem by answering the question “why?” (this refers to why the tree was sick). As the participants gave answers to the “why?” question, some roots were drawn on the tree. These represented the causes of the sickness, thus the suggested causes were written on the roots. Upon the identification of the causes, the “why?” question was repeated in order to identify the secondary causes of the sickness. As more causes were identified, the root of the tree branched out, and the causes were written on the roots. The participants were asked the “why?” question several times until they could no longer identify the secondary causes.

The participants were later asked to identify the primary impacts of the problems by asking them the question “what happened?” (this refers to the effect of the sickness on the tree). A tree branch had to be drawn for each effect, and the identified effect was written on that branch. The question “what happened?” was repeated for each identified effect in order to identify the secondary effects. Some leaves were drawn on the branches, on which the secondary effects were written. The participants were asked the “what happened?” question several times until they could no longer identify any effect of the problem.

After asking the necessary questions, the relationship of the problem with climate and climate change was established. The problem trees were kept as bases for identifying the “adaptation options”, and for developing the “adaptation strategies”.

The Finding Solutions tool allowed the farmers to brainstorm on ideas to solve the identified problems. The problems that were identified during the Root Cause Analysis were written down on a face of a sun. The participants were asked to come up with possible solutions to the identified problems. Identified solutions were written at the end of the sun rays. Furthermore, the participants were asked to think of how to achieve each of the general solutions that they identified. The answers were written on the rays as solutions. These were considered as potential adaptation measures. More new rays were added for the new solutions that were identified during the discussions. All the

rays were well checked to see whether they added up to a full solution to the identified problem.

A further discussion was held to identify the adaptation options that would be more effective than others. Those that the participants considered ineffective or difficult to implement were discarded. The participants were asked to give reasons for the chosen options, particularly because some of them might be more effective than others. The effectiveness of existing coping mechanisms was captured.

4.8. Data Capturing

Data capture did not require any sophisticated software, since all the collected data was in form of text. During the focus group meetings, the responses from the participants were noted on flip charts, after which they were summarized. The key results of this study are presented in Chapter 5.

4.9. Data Analysis

Qualitative data collected through consultative meetings were summarized in order to help the researcher understand and interpret what could be deduced from them. The findings were categorized in four different themes which are linked to the research objectives. Some of the data was presented in tables and in diagrams. For the purpose of this research, the researcher used the interpretive paradigm to identify the multiple realities present in the collected data (Maree, 2007). Quantitative data was collected mainly to quantify the number of research participants, as representatives of their respective constituencies.

4.10. Limitations

Collecting information through the focus group discussion sessions was a good approach to obtaining information from a group of people at the same time. This however does not guarantee that the experience shared by the representative population is not the only experience for the whole Ohangwena Region. Nevertheless, the group sessions held represented the respective constituencies, which overall represent 36% of the constituencies within the region. Such a proportion was deemed valid to give an idea of how farmers in Ohangwena Region are impacted by, and cope with climate change.

CHAPTER 5: CLIMATE CHANGE, IT'S IMPACT AND ADAPTATION STRATEGIES IN OHANGWENA REGION

5.1. Introduction

This chapter presents the results of the study. It particularly focuses on the climate patterns being observed within the Ohangwena Region, on the impact of climate variability and change on agriculture in the region, and on the adaptation strategies for the changing environment as a result of climate variability and change. The information contained herein has been presented in such a way that major findings have been grouped under five different headings; whereas specific findings from each of the four focal constituencies have been presented separately under different sub-headings. In addition to the specific findings presented from each constituency, comparisons of findings from all four constituencies have been made and discussed.

All the climate change related information such as occurrence of rainfall and the seasons when agricultural activities take place have been presented under a heading: "Evidence of climate variability and change in Ohangwena Region". Similarly, information on how farmers and farming activities are impacted by climatic events of floods and drought is presented under a section: "Impacts of climate variability and change on agriculture". Another section: "Adaptation and coping strategies for climate variability and change" presents information on how farmers cope with the climatic events and how they would like to secure their future survival during those events. Furthermore, there is section on the causes and effects of climate change experienced by the farmers, which has been presented under a heading: "Root cause analysis of climate related problems in agriculture". Finally, a section under a heading: "Possible future adaptation strategies for climate change and variability" has been presented, documenting a number of future adaptation strategies that have been proposed by farmers.

5.2. Evidence of Climate variability and change in Ohangwena Region

This research attempted to ascertain whether the selected communities have noticed any change in the climate patterns over the years. During the focus group discussions, the representatives from the four selected constituencies gave their views regarding the observed climate patterns. This included sharing opinions based on their local knowledge. They also gave a highlight on issues around the occurrence of floods. The responses from individual constituencies were as follows:

5.2.1. Evidence of climate variability and change in Endola Constituency

Farmers in Endola Constituency have noticed that there is a change in the climate patterns. Based on their knowledge, the rainy season that supports agriculture used to start in mid-October to November, which was the time they used to start cultivating their fields in the past. However, this is no longer the case. Cultivation of fields is usually delayed by the delayed rainfall these years, and is now known to start in January or sometimes in February. This is also the time that rainfall tends to be intense.

One farmer said: "*In the past, rainfall used to start in mid-October or November, which used to be the cultivation time but is no longer the case*."

As part of collecting data on climate related information, farmers were asked to provide information on the seasons when the rainfall is received, when planting is done, when harvesting is done and the periods when water stays in the oshanas. Such information was collected using the seasonal calendar tool. The participants gave an indication of the noted seasons in relation to climate patterns, giving particular attention to the seasonal calendars for the years 2008/2009 and that of 1994/1995. The results are presented in Table 3.

Table 3. Seasonal Calendars for the years 2008/2009 and 1994/1995 based on farmers' experience in the Endola Constituency

Calendar Year	2008/2009				1994/1995			
Duration	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**
Rainfall Season	October	November	January	April	September	December	January	May
Planting Season	October	December	February	March	November	January		
Harvesting Season	May	June			April	June		
Period of water in oshanas	December	July						
Dry season			August	November				

In the past, farmers used to practice using local knowledge to predict the rainfall. This used to be done by observing the wind direction in September. According to the farmers, whenever the wind was blowing from south-east to north-west in September, it was a sign that there would be good rains and bountiful harvests. Additionally, the farmers indicated that the weather used to get very cold in the past, to the point of killing plant leaves, which it is no longer observed these years.

"*We used to experience very cold weather which could kill plant leaves because it is too cold but in the recent years it does not happen anymore*", said one farmer.

Furthermore, farmers have observed that floods occur when rainfall is heavy, since rainwater can easily fill up rivers beyond their capacities. This causes the rivers to overflow, to the point that the flowing water reaches the cuvelai plains as well as other flood prone areas. Farmers also believe that floods are mostly caused by overflow of rivers in southern Angola after heavy rains, whose water flows all the way to the plains

and the flood prone areas in Namibia. They gave an indication that heavy floods were experienced in 1950, 2008 and 2009.

"Y*es, we experienced heavy floods in 1950, 2008 and 2009. We also experienced heavy rainfall in 1981*", said one farmer.

5.2 .2. Evidence of climate variability and change in Ongenga Constituency

In the view of rainfall patterns, farmers in Ongenga Constituency indicated that there is a noticeable change. They pointed out that the rainfall season used to start in October, raining until May of the following year. However, the rainfall patterns have changed these years. According to the farmers, the rainfall season now starts in January, ending in April. They gave an indication that there has been a significant change in the amount of rainfall received between 2007 and 2010 compared to other years in the past. More rainfall has recently been received. Farmers also indicated that the rainfall season of 2009/10 appeared to be normal compared to the previous years. During the PRA exercise, they gave their views on the noted seasons in relation to climate patterns, during the calendar years of 2008/2009 and that of 1994/1995 (see Table 4).

Table 4. Seasonal Calendars for the years 2008/2009 and 1994/1995 based on farmers' experience in Ongenga Constituency

Calendar Year	2008/2009				1994/1995			
Duration	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**
Rainfall Season	September	December	February	April	September	December	February	May
Planting Season	November	February			November	January		
Harvesting Season	May	June			June	July		
Period of water in oshanas	December	May			February	August		
Dry Season	May	August						

Some responses from the farmers were:

"Y*es, we have noticed changes in the climate, especially in the years between 2007 and 2010. We received a lot of rainfall*."

"*In the past, the rainfall season used to start in October, going up to May of the following year. In the recent years it starts raining in January, ending in April*".

"*The years 2008/2009 were very hot compared to the preceding years*".

The farmers further pointed out that the elders used to predict rainfall in the past, for example, using the fruits of the mopane trees. They are now concerned as to whether such things are still happening or whether they are being ignored.

With respect to the general environment itself, the farmers have noticed that there is a change. It has been noticed that there used to be many forests and enough grazing lands within the constituency in the early 1970s; however after 1976, many trees have disappeared and the grazing land has been reduced. The farmers have also noticed that trees are dying out and that the weather has been hotter than usual. Due to the noted changing climate, the farmers raised their concern as to what will happen in the coming ten years, especially in the view of uncontrolled activities such as burning of fossil fuels that produce greenhouse gases. The response given to them during the consultation meeting was that, temperatures will become warmer, and extreme events such as floods and droughts will occur more frequently, particularly if the developed countries that contribute more to the greenhouse gases emissions do not minimize their emissions.

The farmers in Ongenga Constituency have figured that there is a distinction between too much water resulting from floods and too much water caused by heavy rainfall, which tend to be referred to as one thing. They made clarity that floods can cause flow of water even when the land is dry, and can sometimes be stopped by rainfall. In

comparison, heavy rainfall can saturate the soil with water until the water level rises. Nevertheless, the farmers feel that floods are caused by water flowing from rivers in Angola, especially after heavy rainfall. According to the farmers, floods in Ongenga Constituency were experienced in 1950, 1978, 2008 and 2009.

5.2.3. Evidence of climate variability and change in Odobe Constituency

As it is the case in Endola and Ongenga constituencies, farmers in the Ondobe Constituency have noticed some changes in the climate patterns. They indicated that the weather used to get cold whenever it rained. Based on their observations, the soil used to retain moisture for at least a week after the rainfall in the past; however, this is no longer the case. They have noticed that soil moisture only lasts for a few days and the soil immediately gets dry.

"*In the past, whenever it rained, the soil moisture could last for at least a week, but nowadays it can rain heavily once and after a few days the soil is already dry*", said one farmer.

The farmers also indicated that they used to experience frost in the past, which used to aid plant growth; however it is no longer the case these years. Frost is not experienced any longer.

"*We used to get frost in the past which could help our crops to grow very well but these years it does not occur anymore*", said one farmer.

During the PRA exercise on the seasonal calendar, the farmers gave their views on the seasonal calendars for the years 2008/2009 and 1994/1995. In this exercise, they provided information on the noted seasons in relation to the climate patterns. The outcomes of the discussions are summarized in Table 5.

Table 5. Seasonal Calendars for the years 2008/2009 and 1994/1995 based on farmers' experience in Ondobe Constituency

Calendar Year	2008/2009				1994/1995			
Duration	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**
Rainfall Season	October	March			October	December	January[2]	March
Planting Season	October	January			October	January		
Harvesting Season	May	June			March	June		
Period of water in oshanas[3]	October	April			January	April		
Dry Season	April	August			April	September		

Regarding the floods, it is felt that water overflowing from rivers in Angola flow all the way down to the flood prone areas in Namibia. The farmers indicated that most parts of Ohangwena Region were heavily flooded in 2008 and in 2009. In addition, heavy floods were also experienced in 1950.

5.2.4. Evidence of climate variability and change in Eenhana Constituency

The farmers in Eenhana Constituency have also noticed that there is a significant change in the climate patterns. They have observed that there have not been many years of good rains in the recent years compared to the past. For this reason, many farmers yield poor harvests, particularly when the very little rainfall is received. The farmers indicated that rainfall was heavy between the months of December and February in the rainfall season of 2007/2008. In addition, they indicated that good rains were received in 1948, during which time there were bountiful harvests which satisfied most farmers. They however pointed out that the rainfall that was received during the

[2] It did not rain in February. After January, the rainfall stopped, and then started again in March, when it also ended.
[3] There was a lot of water in many parts of the constituency in the calendar year of 2008/2009.

rainy season of 2008/2009 reflected a similar pattern experienced over the past years. Regarding the temperature, there was a strong indication that the weather is ever hot despite the season, whether in summer or in winter.

Some farmers' responses:

"*In the recent years (2007 and 2008), we received heavy rainfall between December and February*".

"In 1948, there was a good harvest "eloolo", and fields were very productive. Every farmer was satisfied with what he/she got from the field".

"*The weather is just too hot; it does not matter whether it is summer or winter*".

During the seasonal calendar PRA exercise, the farmers gave their views on the rainfall seasons, planting periods, harvesting periods as well as the periods when water stays in oshanas. The views are presented in Table 6.

Table 6. Seasonal Calendars for the years 2008/2009 and 1994/1995 based on farmers' experience in Eenhana Constituency

Calendar Year	2008/2009				1994/1995			
Duration	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**	**Starting period**	**Ending period**
Rainfall Season	October	October[4]	January	April	September	December	February	May
Planting Season	November	March			November	January		
Harvesting Season	May	June			May	June		
Period of water in oshanas	January	June			December	January		
Dry Season	May	September			May	August		

It is felt that floods result due to heavy rainfall, which fills up rivers in southern Angola beyond capacities, causing them to overflow and flush water to the flood prone areas in Namibia. The farmers indicated that their respective constituency does not experience floods that much; however, the western part of the constituency is more vulnerable to floods compared to the rest of it. Heavy floods in that part were experienced in 1949, 2008 and 2009.

Farmers' view:

"*We do not really experience floods in our constituency; however the western part of our constituency is more vulnerable to floods. The western part of the constituency was flooded in 1949, 2008 and 2009*".

[4] There was no rainfall in November and December.

5.2.5. Comparison of experiences in the four focal constituencies

In general, farmers in all four constituencies have noted a change in the climate patterns. There is a strong indication that the rainy season used to start earlier, around September and October, but these years it tends to be delayed, sometimes starting in January or February. The farmers have indicated that the rainfall that has lately been experienced is no longer as good as it used to be over the past years. Olszewski (2010) has also documented that a considerable change in the rainfall seasons has been experienced over the past three years (including 2010) compared to the previously known weather pattern range. He pointed out that the rainfall received during the rainy season of 2007 was relatively poor, and that drought was experienced too. This was then followed by some years of heavy floods, which were experienced during the rainy seasons of 2007/2008, 2008/2009 and 2009/2010.

Many farmers have attributed the experienced floods to an overflow of rivers in Angola after heavy rainfall. This cannot be doubted because the Cuvelai drainage system in the northern central Namibia is fed by many rivers stemming from southern Angola, which feed the drainage channels (oshanas) in Namibia (Mendelson *et al*., 2000; Mthoko *et al*., 1990). Olszewski (2010) also confirms that the rains flood the Cuvelai delta to the point of overflowing.

Nevertheless, heavy rainfall has impact on the harvest. Due to the fact that there is a strong link between the rainfall received over the past few years to climate variability, there is no doubt that harvests can be impacted. According to Kaperson & Kaperson (2001), climate change will affect agriculture and food security in a variety of ways. It can bring benefits to some areas, while bringing losses to others. In the case of Ohangwena Region, climate change has affected agriculture in such a way that it causes losses in terms of harvests. The farmers yield very little or not at all during both floods and drought events. It should however be noted that floods do not only have negative impacts, they also have a positive side. Floods bring along some fish, and this helps supporting the food insecure communities.

Local knowledge has a very big role in predicting rainfall. This was expressed by farmers from Endola and Ongenga constituencies, a practice that was used in the past. Predicting rainfall using local knowledge has not only been practiced in Namibia, it is practiced in other countries too, for example, Tanzania (Chang'a *et al*., 2010) and in Ghana (Gyampoh *et al*., 2008). However, predicting rainfall using local knowledge has become difficult due to the changes in the climate patterns. Noteworthy, the farmers have noticed the impact of the changing climate in the general environment. This includes: disappearance of forests, dying of plant leaves due to the cold weather, reduction of grazing space, extreme heat, temporary retention of moisture by the soil, poor harvests. It appears that the years of bountiful harvests used to be experienced over 4 decades ago. Farmers in the four constituencies indicated that floods were experienced in 1949, 1950, 1978, 1981, 2008 and 2009. However, the floods that were experienced between 2008 and 2009 were more extreme. There was also an indication that good rains were received in 1948. Noteworthy, it is agreeable that the floods experienced in 2008 and 2009 were not a new experience, since similar events were also experienced some years back. The point worth considering however is that, heavy floods were experienced after some years of drought.

The planting season is mainly between October and March. However, planting is usually determined by rainfall. On average, harvesting takes place between May and June and may start in April or in June. During the 2008/2009 season, harvesting started in May ending in June in all four constituencies, however varied between constituencies in the season of 1994/1995. This suggests that planting is determined by the yields in the fields, and not necessarily by months. According to the results, general periods of water in oshanas vary between years. Over the years 2008/2009 and 1994/1995, the periods of water in oshanas have been observed to be different in the four focal constituencies, however, all falling within the period of December to July, and May to August. Only in one case there was an observation of water in oshanas between October and April. This agrees with the finding by Olszewski (2010), that oshanas in the Oshana Region had water in October, both in 2008 and in 2009.

5.3. Impacts of Climate Variability and Change on Agriculture

Agriculture is impacted by both floods and drought, to the point that farmers experience difficulties. Farmers from the four focal constituencies shared their experiences of the impacts of floods and droughts, as described in the sections below.

5.3.1. Impacts of Climate Variability and Change on Agriculture in Endola Constituency

The floods affect farmers in such a way that those whose agricultural lands are situated in the flood prone areas do not yield any harvest particularly because their fields get inundated with water. At least those farmers whose fields are situated on high grounds yield some, though very little harvest. Both the farmers situated on the low lying areas and high lying areas are equally impacted by drought. They both harvest very poorly or not at all, and their livestock die due to lack of grazing land. As a result of poor harvest, farmers experience hunger. In general, livestock die due to lack of pasture. This is further worsened by drought.

Some farmers' responses on how floods impact crops and livestock:

"*Those farmers who are situated on high grounds at least harvest a little from their fields but those ones situated on low lying areas do not harvest at all since their fields are inundated with water*".

"*The livestock die because there is no grazing pasture*."

The farmers have raised a concern that soils within their agricultural lands are generally not fertile, thus they yield poor harvests. They have noticed that there is no enough organic fertilizer anymore because it gets washed away by flood water. Moreover, farmers experience increasing growth of star grasses in their fields, which are believed to be spread by flood water. Star grass and crops normally compete for fertilizer. Moreover, grazing land is reduced by bush encroachment, which is known to prevent grass from growing. Bush encroachment is a result of overgrazing.

Farmers in Endola Constituency indicated that their fields experience pest infestations during floods. Such pests mainly affect the omahangu crops, to the point of destruction. This means harvesting is also affected. In cases when fields are infested by pests, farmers are only able to harvest what has not been impacted by pests.

Some farmers' comments:

"*The soils have become poor, and there is no organic fertilizer anymore because of so much water*".

"*We do experience pests and most of them attack the omahangu crops. We only harvest what the pest has not destroyed*."

In addition to the pests, farmers experience diseases such as malaria and cholera, as well as animal diseases during floods.

5.3.2. Impacts of Climate Variability and Change on Agriculture in Ongenga Constituency

A similar situation experienced in Endola Constituency of crop fields covered by flood water is experienced in the Ongenga Constituency. With prolonged periods of wet soil, seeds are affected such that they do not germinate. It is worthwhile to note that those farmers who at least get some crops in their fields during good rains harvest very poorly during floods.

Loss of crops due to excessive water is further worsened by pest infestations. As it is the case in Endola Constituency, farmers in Ongenga Constituency experience pests during floods. They have stressed that army worms are the types of pests that are mostly experienced, and that they cause total crop destruction.

Farmers' views about the army worms:

"*Yes, we do experience pests, especially army worms and they totally destroy our crops, mainly omahangu and beans. Once the worms attack a field, one can only harvest very little, which has not been touched*".

Locust infestation is also experienced in this constituency. Locusts are said to have adverse impacts in the crop fields too. Pest infestations significantly affect the harvest, particularly because the areas which are impacted do not yield any harvests. Thus, if large areas of fields are infested, the harvest is very little. Farmers indicated that the fields that are next to oshanas are more vulnerable to pests. Further to the negative impacts caused by pests, birds also tend to attack the omahangu fields, and this affects the harvest too.

More views and concerns from farmers:

"*We also experience locust attacks in omahangu fields. Locusts feed on omahangu leaves, and are very dangerous when they attacks your field*".

"*We also experience bird attacks in our fields, feeding on omahangu seeds*".

In addition to the difficulties experienced with respect to crop production and harvests, floods have some impact on livestock. When floods are extreme, they can sometimes spread water to the kraals. Consequently, livestock survival gets affected, unless they are relocated. In the case of drought, farmers experience livestock losses due to poor grazing pasture. According to the farmers, livestock losses due to drought have been recently experienced, before the flood events of 2008 and 2009.

"*Sometimes there can be heavy rainfall at night and you may find the kraal under water in the morning. Your animals can only survive if you relocate them*", said one farmer.

It is worthwhile to note that the impacts of floods experienced in Ongenga Constituency are not only related to crop and livestock losses, diseases have been experienced too. Both human diseases and animal diseases such as diarrhea have been experienced. Loss of human lives due to floods has also been experienced.

"*We have also lost lives for our relatives who drained in flood water*", said one farmer.

5.3.3. Impacts of Climate Variability and Change on Agriculture Ondobe Constituency

Extreme floods experienced in Ondobe Constituency have severely impacted harvests in many crop fields. During the flood events, many farmers only yield very poor harvests. Some do not harvest at all. Farmers in this constituency associate floods with weed. They have indicated that more weeds grow in their fields during floods, and have a tendency to compete with crops for space. According to the farmers, many fields are usually covered by star grasses, and these are believed to have been brought along by flood water. Weeds are known to affect crop harvests.

One farmer's concern:

"*Flood can bring so much water to the point that we do not harvest anything from our fields, only a lot of weeds that grow in there*".

As it is the case in Endola and Ongenga constituencies, farmers in the Ondobe Constituency also experience pest infestations, which cause crop destruction, especially omahangu and beans. According to the farmers, heavy pest infestation was experienced in 2008. The types of pests experienced were mainly: "*oshihenene*" (Common name in English not known, but is a worm), cut worms "*ombovi*" and locusts "*oshipaxu*". Farmers also experience bird attacks on crops. They indicated that pests are often wide spread, especially in the vulnerable areas.

"*Yes we do experience pests, especially in 2008. Pests like oshihenene, ombovi (cut worm), oshipaxu (locust) and eenghuti (doves) badly destroy omahangu crops and beans*", said one farmer.

Livestock losses have also been experienced due to floods in this constituency. Apart from losses due to floods, many losses have also been experienced due to drought. As a result of drought, grazing pastures become poor and do not provide enough for the livestock. In addition to the drought impact on grazing land, floods can also reduce grazing space. Farmers in Ondobe constituency do not only experience crop and animal losses, they also experience animal diseases, such as lung disease and diarrhea.

One farmer said: "*We experience animal diseases like lung disease and diarrhea*".

5.3.4. Impacts of Climate Variability and Change on Agriculture in Eenhana Constituency

The farmers indicated that crop fields in Eenhana Constituency do not really get affected by floods, but rather by heavy rainfall, especially the one experienced in 2008 and 2009.

"*Our fields do not really get affected by floods, they only get affected when there is too much rainfall, especially in 2008 and 2009*", said one farmer.

Harvests have lately been poor, and the farmers suffer from hunger. The farmers have also indicated that they experience a lot of star grasses, both during floods and droughts. This type of grass badly affects their fields. It gets scattered all over the fields, which makes cultivation and ploughing difficult.

In the presence of too much water, farmers in Eenhana Constituency experience pests. The types of pests experienced include bore worm "*einyo*", corn cricket "*elindi*" and locust "*oshipaxu*". These pests mainly affect the omahangu crop and beans. Farmers

also experience field attacks by birds. These invasions lead to poor harvests. However, despite their impacts, controlling pests is a challenge to the farmers.

This is how some farmers responded:

"*Yes, we do experience pests like boreworm, corn cricket and birds. Pests often come when there is too much water and this mostly affects omahangu and beans. Once we have pest infestations in our fields, our harvests are usually very poor*".

"*We also experience a type of pest that looks more or less like locusts and it can cause serious damage to the omahangu crops*".

As a consequence of too much rain water, survival of cattle and goats becomes difficult. The cattle often fall in a state that is referred to as "survival of the strongest". This means only the strongest cattle can survive in situations when grazing pasture is poor. The weakest ones usually die as a result of poor grazing pasture. Additionally, grass does not grow well in the presence of so much. As a result, food availability for cattle becomes poor. Goats mainly die when water levels are very high, and not always due to lack of food availability.

"*Our livestock hardly survive because grass does not grow so well when there is too much water. The strong ones survive while the rest die due to lack of grazing pasture*", said one farmer.

The farmers pointed out that livestock tend to give birth to premature offspring during drought seasons. It is however questionable as to whether this is a result of a certain disease, or it is hunger that causes this. Consequently, some farmers move their livestock to Angola for better grazing pastures.

Further to the difficulties experienced as indicated above, farmers in this constituency experience diseases. The type of disease that is mostly experienced is mainly diarrhea, both in animals and humans, especially children.

5.3.5. Comparison of Climate Variability Related Problems Experienced in the Four Constituencies

Communities in the flood prone areas are more vulnerable to floods. This has been confirmed in other regions in northern Namibia other than Ohangwena (OPM, 2008). It has also been observed in other parts of the world, for example, Bangladesh (Banerjee, 2006), Ghana (Armah *et al*., 2010) and Kenya (Ongwenyi *et al*., 1993). Very poor harvests are yield during floods, or no harvests at all. This is the same situation when there is drought. At least those farmers who stay on high grounds yield some harvests compared to those on low grounds. In the case of drought, effects on both high and low grounds are the same. This means that farmers on either location are equally impacted by drought. Hunger is the result of poor harvests, both during floods and drought. A study by Kaperson & Kaperson (2001) confirms this, as it has concluded that the number of people at risk of hunger may increase as a result of climate change. It should be noted that drought and floods equally impact both the crops and livestock. According to the statistics on the floods impacts in the Ohangwena Region, the number of farmers whose crop fields were destroyed in 2009 was 5671, while the total number of livestock that were lost was 2161 (FEMCO, 2009). In addition, many studies have confirmed that agricultural losses (both crops and livestock) are experienced during floods and drought (Ongwenyi *et al*., 1993; McCarl *et al*., 2001; Wang, 2005; Devereux, 2007).

During floods, farmers experience weeds. Such weeds, for example, star grasses are known to be brought along by flood water. As a result, weeds get in competition with crops for fertilizer and space. This leaves the farmers with a challenge of dealing with the weeds, while at the same time giving priority to the survival of their crops. It is worthwhile to note that the two types of events, both drought and floods reduce grazing space. In situations where grazing space is reduced, overgrazing is experienced. Such a condition leads to bush encroachment, which has been experienced in one of the

focal constituencies for this study. This suggests that there could be more constituencies that experience bush encroachment too, and that the issue needs to be addressed. In general, bush encroachment causes problems to rural farmers, since invasive bush species make large areas of land unusable. As bush encroachment worsen, the rangeland conditions become poor; however, given the changing and variable climate, livestock survival will be threatened if the rangelands are not well managed.

Pest infestation is a challenge to farmers in all the focal constituencies for this study. Farmers have indicated that pests are mainly experienced during floods, and can be experienced during drought seasons too. Pests are considered as limiting factors to crop production. In many cases, severe pest infestation can cause crop losses. A number of pests have been identified by the farmers from the four different constituencies. The identified types are: cut worms, locusts, bore worms, corn crickets, oshihenene (name not known in English, but is a worm) and birds. Pests such as army worms cause early stand defoliation, while cut worms cause seedling loss and stalk injury. Locusts are known to cause reduction on crop yields and quality.

Apart from the flood impacts highlighted earlier, human and animal diseases can be experienced as a result of floods. This is in agreement with a study by Kaperson & Kaperson (2001), which emphasized that global warming threatens human security and well being through increased exposure to vector-borne diseases and waterborne diseases. Malaria, cholera and diarrhea are mainly the diseases that have been experienced among humans; while diarrhea is the common animal disease that is often experienced.

Many farmers have experienced livestock losses due to floods. High water levels can cause animals to drown, especially goats. This can be confirmed by the statistics from Ohangwena Region for the year 2009, which reported a loss of 299 cattle, 10 donkeys, 1826 goats and 26 sheep (FEMCO, 2009). Apart from the loss of animal lives, loss of human lives is also experienced during floods. A total of 22 cases of drowned people in

Ohangwena Region were reported during the flood event of 2009 (FEMCO, 2009). In addition, 100 flood related deaths were reported in Namibia during the flood event of 2008 (OPM, 2008).

5.4. Coping and Adaptation Strategies for Climate Variability and Change

The primary source of livelihood in Ohangwena is subsistence farming and labour migrations, supported by a variety of income-generating activities and the provision of casual labour (GIB, 2009; NPC, 2004). The farming system is dominated by millet cropping '*omahangu*', combined with cattle rearing. Omahangu is the preferred crop due to the fact that it is drought resistant, as it can tolerate high temperatures and can grow in areas with less or no water (NPC, 2004). As a coping strategy for the handling the field products, farmers store their harvests in grain storage baskets (Nunes *et al*., 2010). In addition to their reliance on field products, they also depend on natural resources for food. Livestock are taken to cattle posts or to Angola for better grazing pastures.

The farmers provided information on the sorts of actions taken during the events of floods and drought. They also gave an indication of the kind of help that they would need to help them survive during such events. Their experiences and views are described in the sections below.

5.4.1. Coping and Adaptation Strategies in Endola Constituency

At the moment, famers in Endola Constituency do not have any coping strategies in place to employ when fields are inundated with water. However, they relocate to high grounds and move to back to their homes when the water levels get low. Some farmers completely leave their houses and do not go back to the same locations after the water levels become low. Nevertheless, relocating to high grounds does not at all aim to protect the fields from excessive water.

Farmers' responses to the questions regarding the strategies employed when 1) crop fields are inundated with water, and 2) when households are flooded:

1). “*We do not do anything*”.

2). “*Yes, we relocate to high grounds and move back to our homes when the water levels get low. Some people leave their homes for good and never return back*”.

Given the crop and livestock losses that they experience during floods and drought events, farmers are usually left in difficult conditions. Both livestock and crops are equally impacted by the events of floods and drought. At least they receive some drought relief from the government. Unfortunately, farmers do not get any compensation for any loss of crops or livestock.

Due to the difficult conditions they are often left in by the drought, the farmers would like the government to ensure that they receive sufficient drought relief. They have also proposed that pension funds should be increased since pension is one of their major sources of income, which they can rely on when conditions are extreme.

With the changing seasons, a variety of natural resources become readily available. Farmers often use such resources to supplement their diets. The natural resources in which the farmers depend for food are listed in Table 7.

Table 7. Types of natural resources on which the farmers in Endola Constituency depend for food

Common Name	Scientific Name	Name in the local language
Bird plum fruits	*Berchemia discolor*	Eembe
Wild spinach		Ombidi
Corky monkey orange fruits	*Stychnose cocculoides*	Omauni
Jackal berries	*Diospyros mespiliformis*	Eenyandi
Manketti fruits	*Schiziophyton rautanen*	Omanghete
Marula fruits	*Sclerocaryca birrea*	Eengongo
Frogs		Omafuma
Mopane worms	*Imbrasia belina*	Omaungu
Fish		Eeshi

5.4.2. Coping and Adaptation Strategies Ongenga Constituency

Inundation of crop fields is quite a challenge to the farmers in Ongenga Consituency. It appears that they have no strategy in place with which to protect their crops when the fields are inundated with water, thus they do not take any action in such situations. In actual facts, skills and knowledge to respond to the events of drought and floods are currently lacking. What farmers usually do is to relocate to high grounds when the water levels are high, and go back to their households when the water levels become low. Livestock too are moved to high grounds when water levels are high. Some farmers leave their homes during the floods and never return back even when the land gets dry.

The farmers' responses regarding the inundation of crop fields and flooding of households were as follows:

"*We do not do anything, because we do not have the skills or knowledge on how to respond to such incidences*". This refers to situations when the fields are inundated with water.

"*Yes, we relocate to high grounds. We only come back when water levels become low*."

"*Some people have left their houses completely and have never returned back*".

Crops are the source of subsistence for farmers in Ongenga Constituency and are not grown for the purpose of income generation, thus they always see crop loss as food loss and not as income loss. However, excess products could be sold in the past. Nowadays, harvested crop products are only stored in grain storage baskets.

In spite of the crop losses that farmers experience, they make use of natural resources as food. Nevertheless, such resources are only available during certain seasons. The types of resources that farmers in Ongenga Constituency utilize are listed in Table 8. Some resources, for example, wild spinach do not grow well when fields are inundated

with water. According to the farmers, wild fruit trees no longer produce enough fruits as it used to be the case in the past. Many wild fruit trees lose their flowers during heavy rainfall and strong winds, and this affects their productivity.

Table 8. Types of natural resources on which the farmers in Ongenga Constituency depend for food

Common Name	Scientific Name	Name in the local language
Bird plum fruits	*Berchemia discolor*	Eembe
Wild spinach		Ombidi
Corky monkey orange fruits	*Stychnose cocculoides*	Omauni
Jackal berries	*Diospyros mespiliformis*	Eenyandi
Manketti fruits	*Schiziophyton rautanen*	Omanghete
Marula fruits	*Sclerocaryca birrea*	Eengongo
Frogs		Omafuma
Mopane worms	*Imbrasia belina*	Omaungu
Fish		Eeshi
Grewia fruits	*Grewia spp.*	Eeshe
Palm apples	*Hyphaene ventricosa*	Eendunga
Bushman's orange		Omapwaka

Although farmers are often left in serious predicaments by the floods and drought events, they do not get any compensation for any of the losses. However, they receive some food aid during drought. In order to secure their future survival in the face of the changing climate, they would like the government to increase their pension funds. Farmers would also like the amount of drought relief to be increased. They have also proposed that they need some form of environmental education and training with respect to adapting to climate change. A request was also made for them to be supplied with seeds that can survive in a lot of water.

Generally, floods limit people's access to social services, such as churches, schools and clinics, for that reason, farmers would like the common roads to be upgraded with bridges. They would also like to be provided with food for their animals during the floods and drought events, and to be supplied with artificial fertilizer. Furthermore, they would

also like their livestock to get immunized since they become vulnerable to diseases during floods and droughts.

Some of the comments made by the farmers regarding the kind of help they will when impacted by drought and floods were:

"*We need enough drought relief. The pension fund should also be increased because we depend on it during floods*".

"*We need some sort of education and training on adaptations to climate change*."

"*We also need seeds that can strongly survive in a lot of water*".

"*We need bridges that can help us have access to schools, clinics and other social services during floods*".

"*We need food for the animals, artificial fertilizer and immunization for our livestock*".

5.4.3. Coping and Adaptation Strategies in Ondobe constituency

As it is the case in Endola and Ongenga constituencies, farmers in Ondobe constituency do not have any control over their crops when fields are inundated with water. Therefore they do not take any actions in such situations. They pointed out that floods affect both crops and livestock equally. In addition, they have observed that crops tend to die when fields are inundated.

"*We do not do anything*", said one farmer in response to the question on the kind of strategies they use when the fields are inundated".

The farmers further pointed out that they move to high grounds when houses are flooded, and return back when the water levels become low. "*We do relocate to high grounds, and only come back when the water levels become low*", said one farmer.

Moreover, they indicated that grass does not grow well anymore these years, thus, the livestock survival is affected. It has also come to a realization that the extent of grassland has been reduced, while the number of bushes is increasing. Bush encroachment is therefore regarded as a contributing factor to the reduced grazing land. However, only cattle that being grazers are affected by such a condition, unlike goats that can browse.

The farmers in Ondobe Constituency do not grow crops for selling purpose, as they entirely depend on them for subsistence, thus they only see crop loss as food loss, and not loss of income. To ensure survival during extreme periods, they store their crop products in grain storage baskets. In addition to dependence on crops for subsistence, farmers supplement their diets with natural resources, mainly during the rainfall season. The types of natural resources in which they depend are listed in Table 9.

Table 9. Types of natural resources on which the farmers in Ondobe Constituency depend for food

Common Name	Scientific Name	Name in the local language
Bird plum fruits	*Berchemia discolor*	Eembe
Wild spinach		Ombidi
Corky monkey orange fruits	*Stychnose cocculoides*	Omauni
Jackal berries	*Diospyros mespiliformis*	Eenyandi
Manketti fruits	*Schiziophyton rautanen*	Omanghete
Marula fruits	*Sclerocaryca birrea*	Eengongo
Frogs		Omafuma
Mopane worms	*Imbrasia belina*	Omaungu
Grewia fruits	*Grewia spp.*	Eeshe

The farmers indicated that they used to store some food supplements (i.e. omahangu and sorghum residues) for their cattle in the past; however, with very poor harvests this does not happen anymore. They are therefore concerned about their livestock survival. Nevertheless, in the face of unfavorable conditions, some animals have started to adapt to new living conditions, for example, goats have learned to feed on grass covered by water like donkeys. This is an unusual behavior for goats, which was observed in 2008/2009. Moreover, due to limited grazing space, some farmers move their cattle to Angola for better grazing pastures.

To secure their future survival during drought and flood periods, farmers in this constituency would like to get some support from outside. They would like to get enough drought relief in order to combat the hunger strike that often challenges the community during drought periods. Furthermore, having the pension funds as the source of income, they would like to receive some increases in order to be able to effectively support their families. They would also like to get some training and education related to adaptation to climate change, and to be supplied with the types of seeds that can survive in a lot of water. Farmers also feel that it is essential to have dams for collecting running water and store it for future consumption.

The farmers' comments regarding the kind of help they would need during extreme conditions were as follows:

"*We need enough drought relief*".

"*The pension fund amount needs to be increased because we depend on that money during the floods*".

"*We also need some education and training on how to adapt to the changing climate*".

"*We need seeds that can survive in a lot of water*"

"*We need dams that can collect the running water and store them for future use*".

5.4.4. Coping and Adaptation Strategies in Eenhana Constituency

Farmers in this constituency also have no control over their fields when they are flooded. Hence they do not do anything to protect their crops in such situations. The only action they take is to move their families and livestock to high grounds, with help from the regional councilors. Sometimes they go stay with their relatives until the water levels get low. Situations may force them to stay away from their houses for up to 2 months; however the duration of their stay is determined by the water levels. Such an action contributes to the survival of their animals too, since they can drown in too much water, especially the goats. Some farmers move their livestock to Angola for better grazing pastures.

This is how they responded:

"*We do not do anything".* This is in cases when the fields get inundated.

"*Yes, we move our houses and livestock to high grounds or to our relatives. It takes us about two months depending on the water levels. The councilors help us to relocate*."

The farmers indicated that they do not sell crops, thus they see crop loss as food loss and not as loss of income. They pointed out that the last time crops were sold in their constituency was in 1950, when the harvests were bountiful. Instead of relying entirely on crops for food, they make use of the natural resources to supplement their diets. The types of natural resources which they utilize are listed in Table 10.

Table 10. Types of natural resources on which the farmers in Eenhana Constituency depend for food

Common Name	Scientific Name	Name in the local language
Bird plum fruits	*Berchemia discolor*	Eembe
Wild spinach		Ombidi
Corky monkey orange fruits	*Stychnose cocculoides*	Omauni
Manketti fruits	*Schiziophyton rautanen*	Omanghete
Marula fruits	*Sclerocaryca birrea*	Eengongo
Palm apples	*Hyphaene ventricosa*	Eendunga
Bushman's orange		Omapwaka

Although they can get hardest hit by drought to the point of losing their crops and livestock, they do not get compensated for any loss. Nevertheless, they get some drought relief from the government. They have however indicated that the drought relief needs to be increased, and that they need to be educated on to how to deal with, and adapt to climate change. Regarding the health of their livestock, they would like to have them vaccinated more often. Furthermore, since the soils lose their fertility due to so much water, the farmers would like to be supplied with artificial fertilizer.

Their responses regarding the kind of help that they would need during extreme conditions were:

"*We want the government drought relief to be enough*".

"*We also need to be educated and to be trained on how to deal with climate change and on how to adapt with climate change*".

"*We need the government to assist us with artificial fertilizer and vaccinations for the livestock*".

5.4.5. Comparison of Coping and Adaptation Strategies for the Climatic Events in the four Constituencies

None of the four constituencies has a coping strategy in place for inundated fields. All they do is relocate to high grounds and return to their houses when water levels become low (some do not return at all). The duration of stay is determined by the water level. Generally, no action is taken when the fields are inundated, as there are no skills, neither any knowledge is available to deal with that. In addition, the fact that most of the geographical layout of Ohangwena Region lies within the Cuvelai Delta means that many communities are vulnerable to floods. In the case of the livestock, many animals have to learn to adapt to new conditions, given the unpredictable climate. For this reason, some farmers take their livestock to Angola for better pasture. In actual fact, flood disasters are more experienced by many vulnerable farmers due to their reluctance to relocate to high grounds (OPM, 2008). Furthermore, the fact that there are no early warning systems for floods also contributes to the vulnerability of farmers. Nevertheless, in the absence of coping strategies for floods on crop fields, adaptation strategies need to be in place. This is due to the fact that more floods are likely to be experienced in future, especially in the face of the changing climate. Moreover, adaptation strategies will help to prevent future damage (Schipper *et al*., 2008).

At least the farmers supplement their diets with natural resources. A total of 12 natural resources were identified by the farmers from all four constitutiencies (as summarized in Table 11). These are mainly available during rainy seasons. They have some nutritional content and are preferred by many people even for meals. For example, wild spinach, fish, frogs and mopane worms can be eaten with porridge. The fruits are also tasty. It is however felt that the wild fruit trees no longer produce well as it used to be the case in the past.

Table 11. Summary of natural resources identified by farmers in the four constituencies

Natural Products	Constituency			
	Endola	Ongenga	Ondobe	Eenhana
Bird plum fruits	◘	◘	◘	◘
Wild spinach	◘	◘	◘	◘
Corky monkey orange fruits	◘	◘	◘	◘
Jackal berries	◘	◘	◘	
Manketti fruits	◘	◘	◘	◘
Marula fruits	◘	◘	◘	◘
Frogs	◘	◘	◘	◘
Mopane worms	◘	◘	◘	
Fish	◘	◘		
Grewia fruits		◘	◘	
Palm apples		◘		◘
Bushman's orange		◘		◘

According to the research conducted by the National Planning Commision, Ohangwena is the second poorest region in Namibia", following the Kavango Region (CBS, 2008). The levels of poverty in Namibia were determined using data of the Namibia's household income and expenditure survey of 2003 and 2004 from which two poverty lines: "poor" and "severely poor" were determined. The households with monthly expenditures less than N$262.45 are referred to as "poor", while those households with monthly expenditures of less than N$184.56 are referred to as "severely poor". In Ohangwena Region, the incidences of poor and severely poor households are 44.7% and 19.3% respectively (CBS, 2008). After the Kavango Region (56.5% poor, and 36.7% severely poor), Ohangwena is the second highest region with poor households. The poverty levels in the two regions can be compared to those in the Khomas and Erongo regions where 6.93% and 10.3% are "poor" while 2.4% and 4.8% are "severely poor" respectively. Nevertheless, despite the fact that household incomes in Ohangwena Region are low, farmers don't sell crops. They depend on them for subsistence. At least to the Eenhana Constituency's farmers knowledge, the last time that crops were sold was in 1950, when harvests were bountiful. Many households in Ohangwena Region depend on pension as a source of income (MLSW, 2008).

Farmers in all four constituencies have indicated that despite the crop losses and livestock losses they experience during drought and flood events, they do not get any compensation. At least some drought relief is obtained from the government. They also get flood disaster relief from various sources, including: government, regional councils, NGOs, church authorities, consulting companies, businesses, banks, UN agencies and individuals (FEMCO, 2009). The kind of support they receive can be in form of money, rescue, transport offer, food, medical treatment, basic essentials (e.g. toiletries, mosquito repellents, mosquito nets and candles) and tends. Efforts are also placed on providing them with temporary shelter, potable water and improved sanitation conditions (DREF, 2009).

The farmers pointed out that they need support, including increasing pension funds (to support families), offering environmental education with respect to adapting to climate change, provision of seeds that can tolerate a lot of water, improved infrastructure i.e. bridges to allow access to the social services, food for the animals, animal immunization to be done more often and to be supplied with artificial fertilizer. Such kind of support will help them adapt to changing environments as a result of climate change. Further possible adaptation strategies are proposed under subsection 5.6.

5.5. Root Cause Analysis of Climate Related Problems in Agriculture

The participants were asked to list the problems being experienced in their respective constituencies that are related to agriculture. The aim was to determine whether the identified problems are related to climate change. In each constituency, analysis was conducted for two of the listed problems, for the purpose of identifying their causes and effects.

5.5.1. Climate Related Problems in Agriculture in Endola Constituency

The problems experienced in this constituency are mainly: pest infestations, inundation of crop fields, livestock diseases, high temperature, damage of houses by floods, poor

rangeland conditions, human diseases (e.g. malaria and cholera) and lack of drinking water for livestock. Problem analyses for two problems: damage of houses by floods and poor rangeland conditions were conducted. The results are diagrammatically presented in Figures 3 and 4.

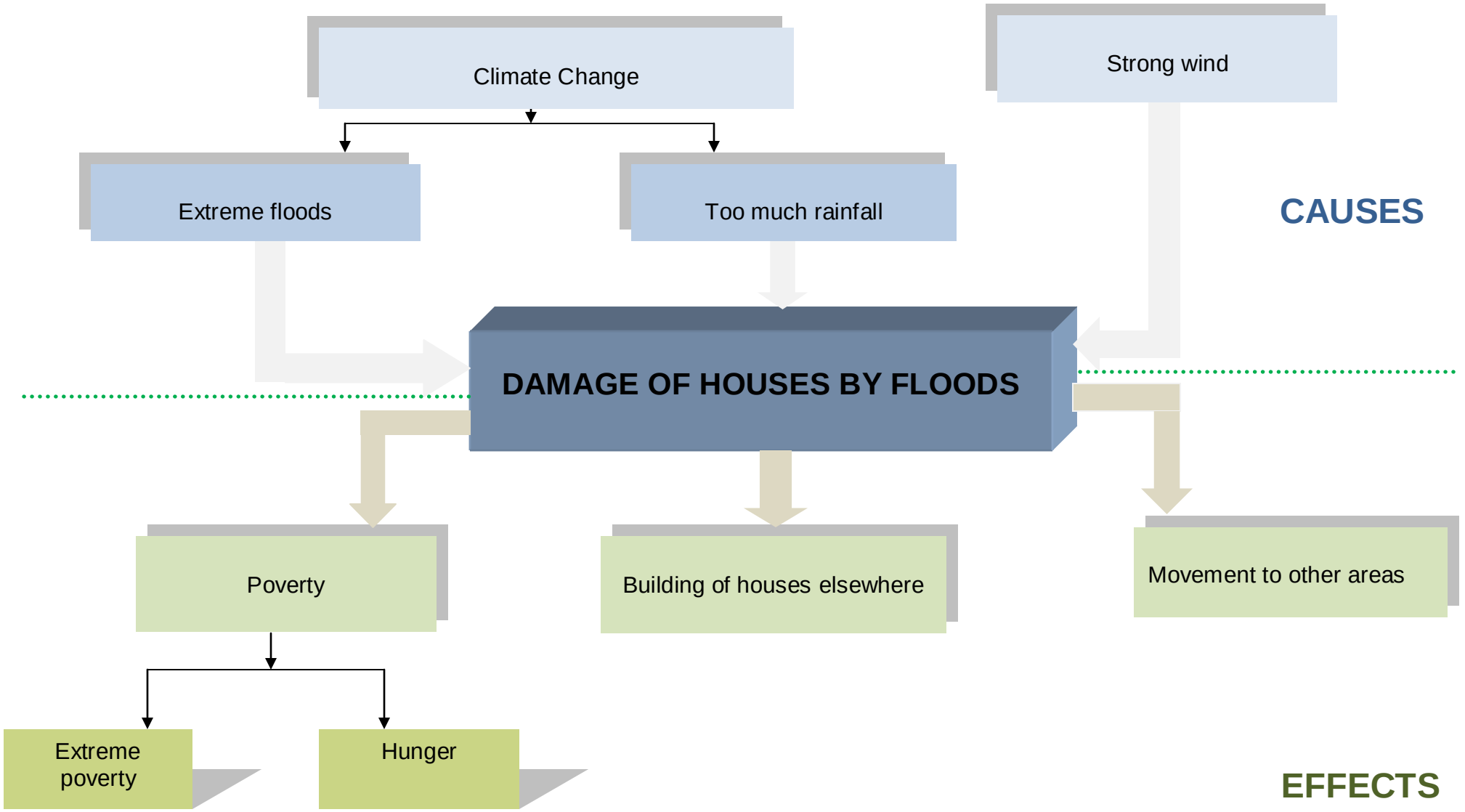

Figure 3. Causes and effects of damaged houses by flood (views from Endola Constituency)

Figure 3 depicts that climate change results in floods and too much rainfall, which contribute to damage of houses. In addition, strong wind contributes to damage of houses. As a result, people end up living in poverty, to the point of extreme poverty and hunger. Some people end up building houses elsewhere, while others move to other areas.

As shown in Figure 4, too many livestock lead to bush encroachment, which contribute to poor rangeland conditions since the grazing land becomes less available. Increasing population size causes development to take place in many villages, to the point that some villages become towns. In the end, the grazing space gets reduced, resulting in poor rangeland conditions. The fact that there are very few formalized grazing areas; the livestock make use of the available grazing pasture, which in the end contributes to poor rangeland conditions. With poor rangeland conditions, deaths of many livestock are experienced. Consequently, many people end up living in hunger, experiencing poverty and do not have organic fertilizers for their fields.

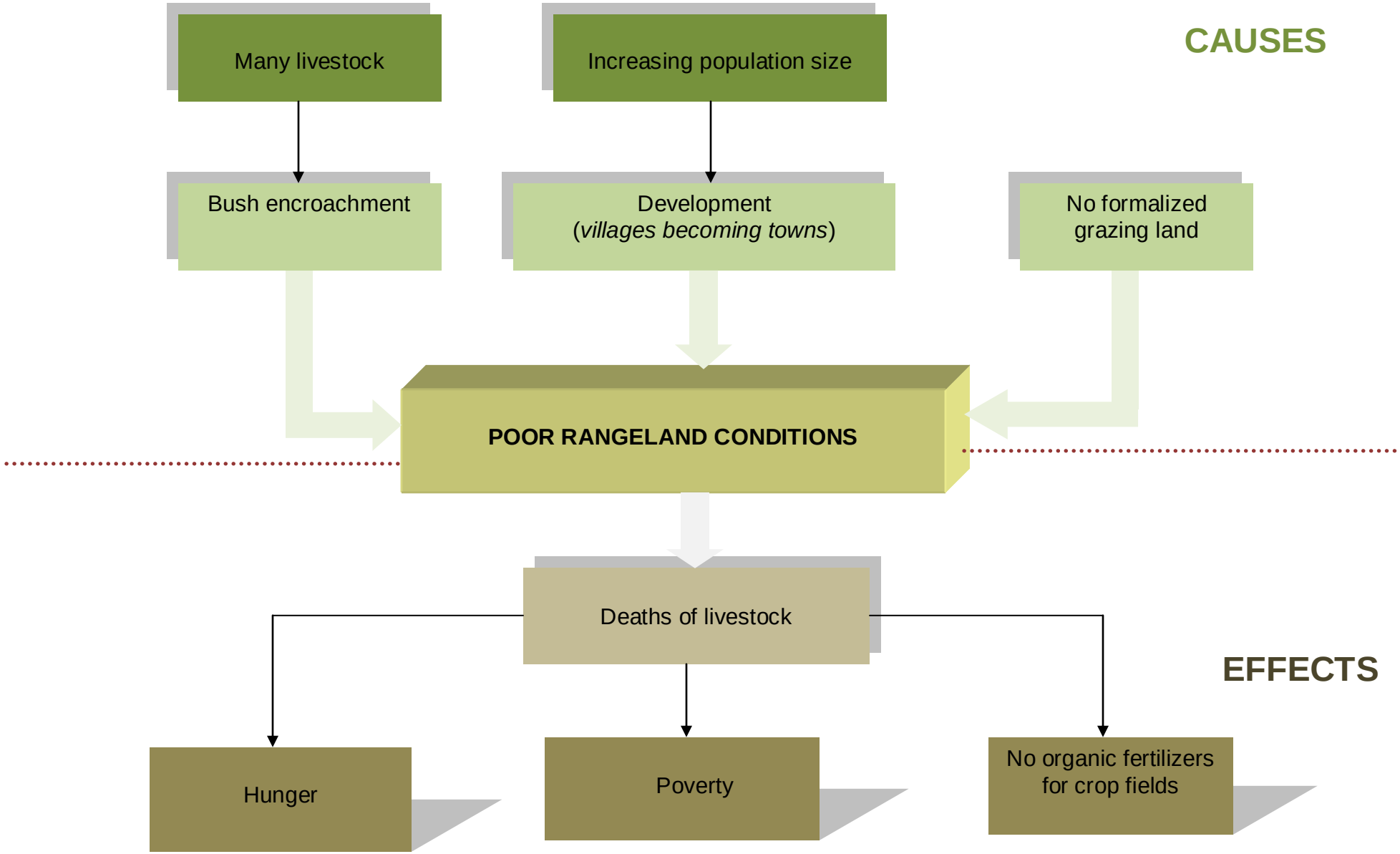

Figure 4. Causes and effects of poor rangeland conditions (views from Endola Constituency)

5.5.2. Climate Related Problems in Agriculture in Ongenga Constituency

Farmers in Ongenga Constituency listed the following as being the main problems facing them: lack of tools for farming activities, animal diseases, lack of water and poor rangeland conditions. Of the listed problems, poor rangeland conditions and lack of tools for farming activities were analysed to get an understanding of their causes and effects, as shown in Figures 5 and 6.

It is believed that traditional and cultural believes cause many farmers to have too many livestock, which can contribute to poor rangeland conditions (Figure 5). In addition, increasing population has led to increased development, which includes villages becoming towns. This leads to poor rangeland conditions. As the climate is changing, too much rainfall is experienced, which also lead to poor rangeland conditions. When the rangeland conditions are poor, often there are no available organic fertilizers for the crop fields, thus many people end up living in hunger and in poverty.

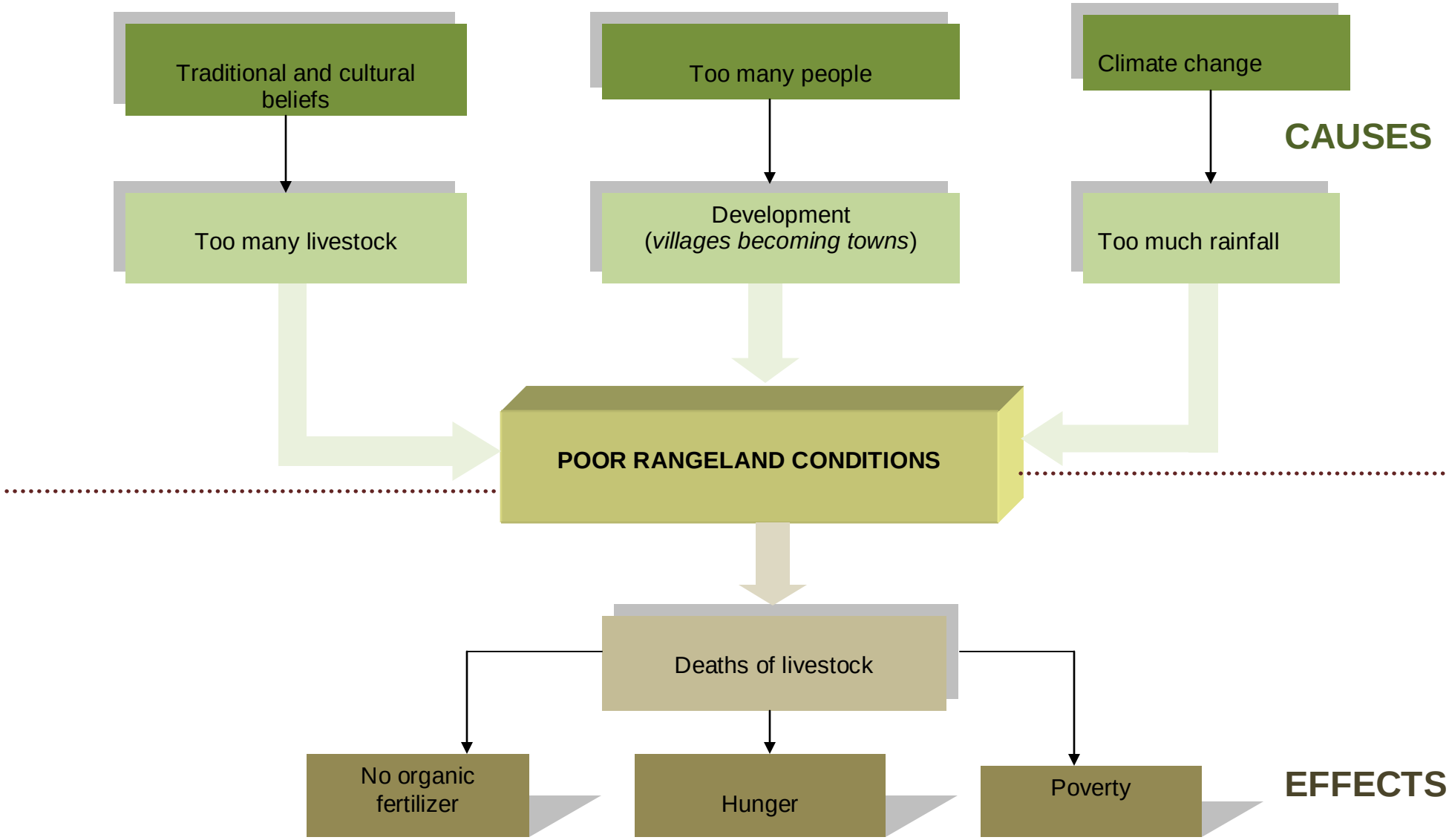

Figure 5. Causes and effects of poor rangeland conditions (views from Ongenga Constituency)

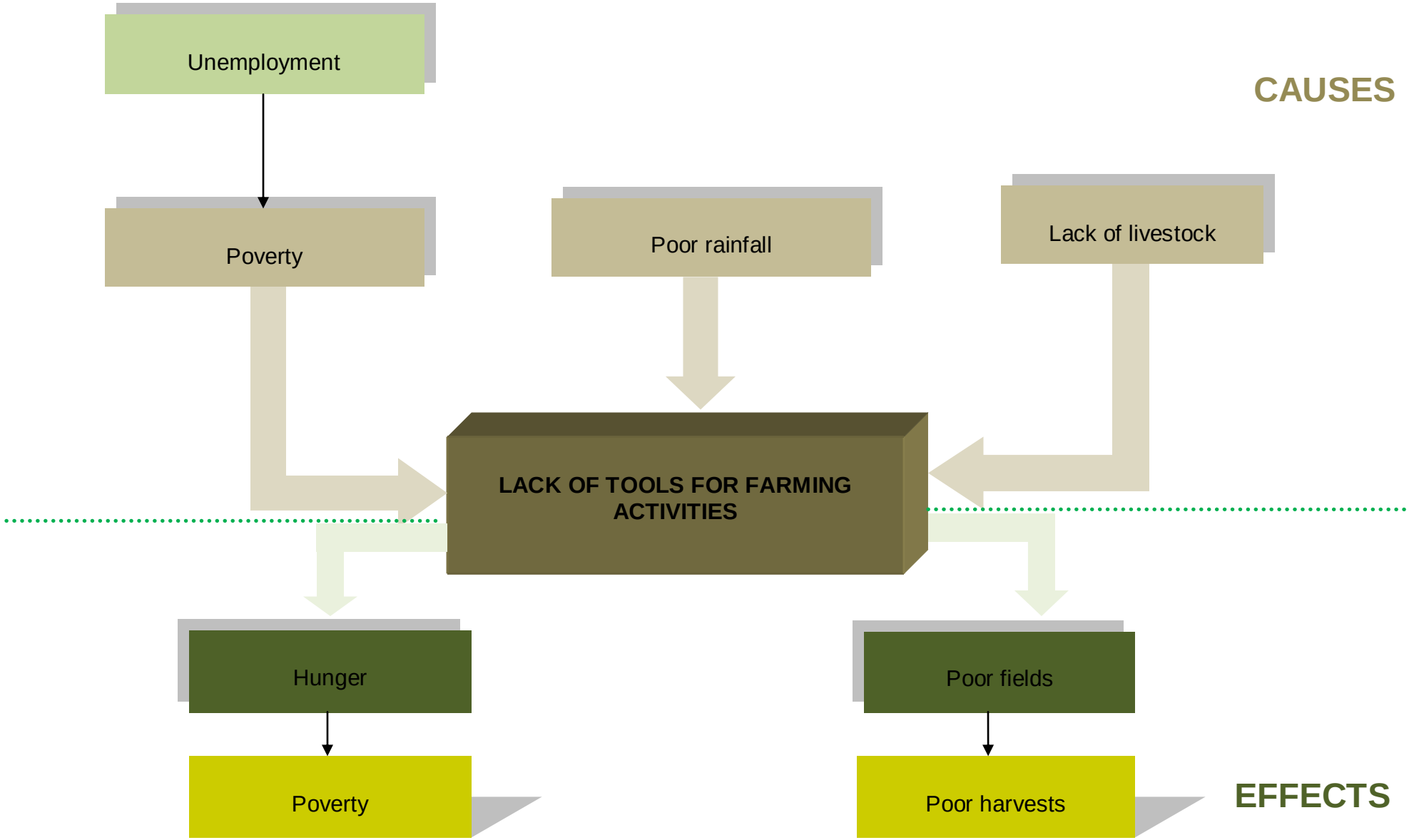

Figure 6. Causes and effects of the lack of tools for agricultural activities (views from Ongenga Constituency)

With respect to the diagram presented in Figure 6; unemployment is known to be the major cause of poverty, and this causes people to be lacking the tools for farming activities. In conditions when rainfall is poor, farmers are often not in position of having tools for farming activities. Moreover, in the absence of livestock, tools for farming activities are also lacking. As a consequence, many people end up living in hunger, a condition which is also believed to lead to poverty. Lack of tools for farming activities also causes the fields to be in poor conditions, leading to poor harvests.

5.5.3. Climate Related Problems in Agriculture in Ondobe Constituency

The problems that have been identified in Ondobe Constituency are: scarce natural resources, wild fruit trees dying, deforestation, lack of grazing pasture/poor rangeland conditions, poor rainfall, pest outbreak, poor harvest, poor nutrient content (organic fertilizers) in the mahangu fields and too high temperature for the crops. Problem analyses were conducted for: poor harvest and poor rangeland conditions. The results of the analyses have been diagrammatically presented in Figures 7 and 8.

As per diagram presented in Figure 7, farmers in Ondobe Constituency have indicated that cutting down of trees lead to poor rainfall, which in the end results in poor harvests. In addition, whenever there are no livestock, there is usually lack of organic matter, and soils become poor and infertile; hence poor harvests. Pest outbreaks also lead to poor harvests. Similarly, as the climate is changing, rainfall becomes too much at some point, which creates conditions of poor harvests. Consequently, people start experiencing hunger, which causes them to be in state of poor health and even die. Due to poor harvests, people end up living in poverty, and may start practicing criminal activities. Furthermore, conditions of poor harvests force the government to provide food aid.

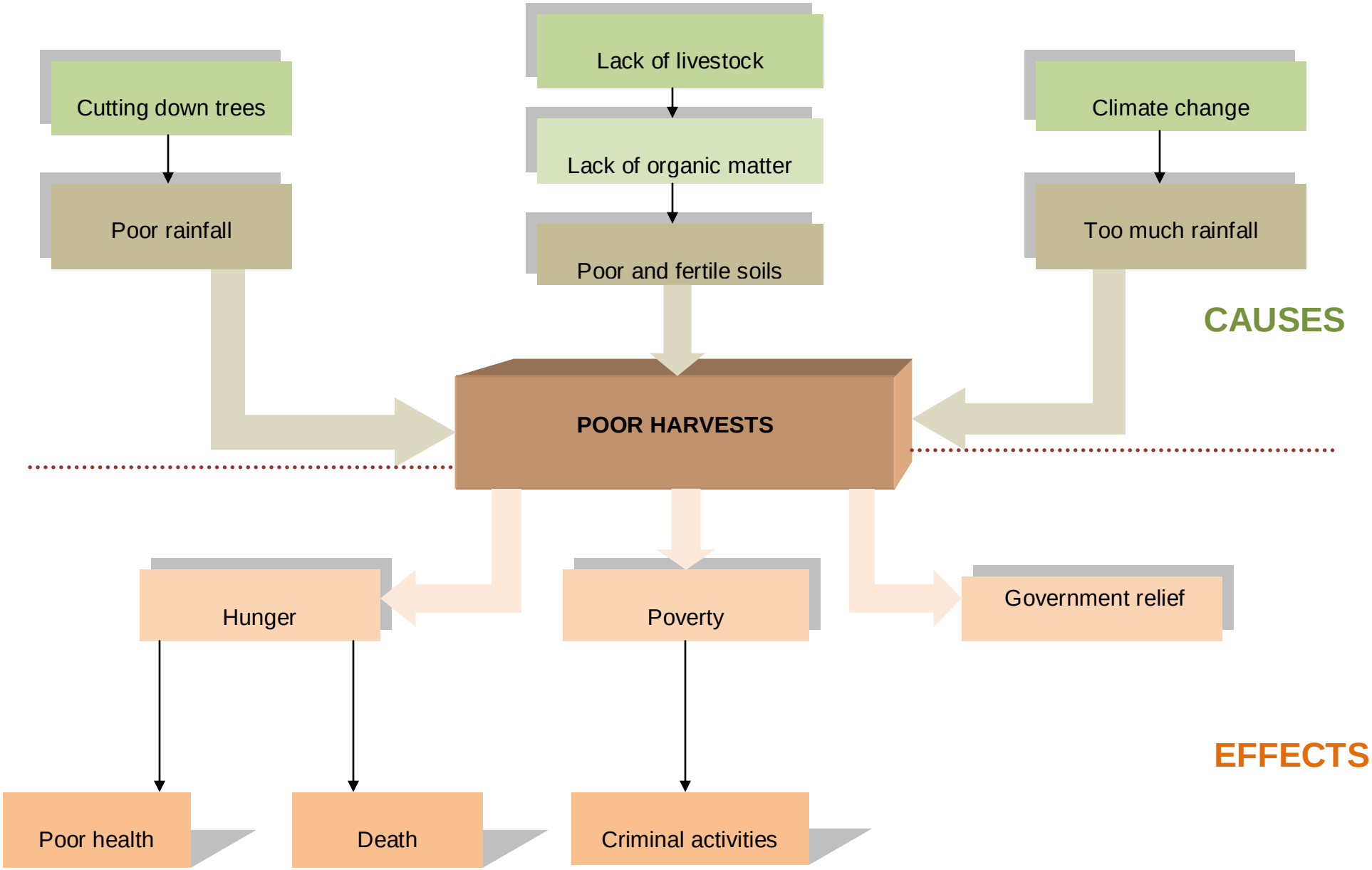

Figure 7. Causes and effects of poor harvests (views from Ondobe Constituency)

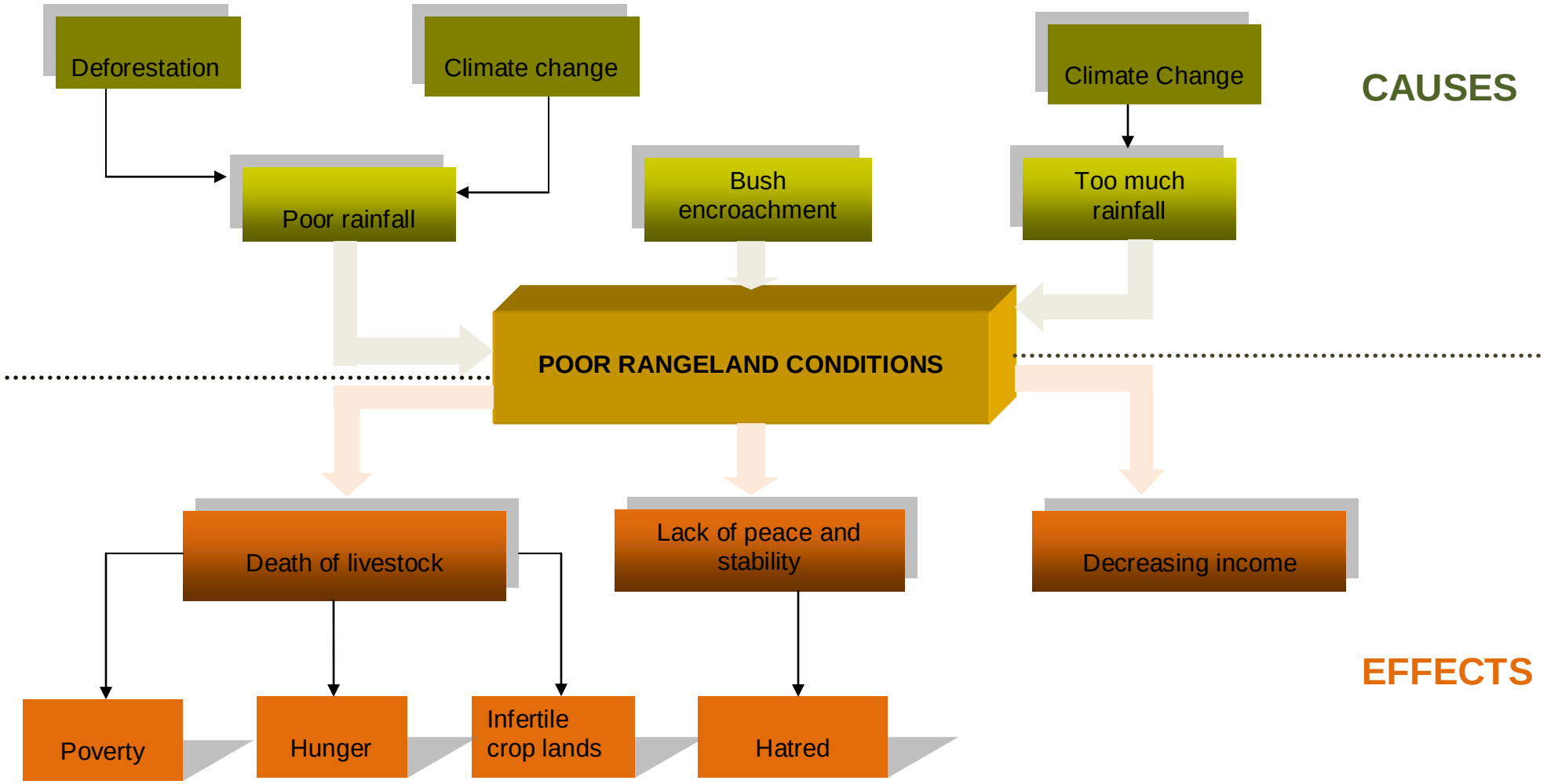

Figure 8. Causes and effects of the poor rangeland conditions (views from Ondobe Constituency)

Figure 8 is a diagrammatical presentation of the problem analysis for the causes and effects of poor rangeland conditions based on the views of farmers in Ondobe Constituency. It is believed that deforestation and climate change cause poor rainfall, and this leads to poor rangeland conditions. The changing climate also causes too much rainfall, which diminish the conditions of rangelands. Bush encroachment also contributes to poor rangeland conditions. As a result, many livestock die and people start to live in poverty, experience hunger and their crop lands become infertile in the absence of cattle manure. When rangeland conditions are poor, peace and stability starts to lack in the society, as their livestock lack food. For this reason, some people end up being in hatred. Additionally, poor rangeland conditions cause a decrease in income, particularly those farmers who depend on their livestock for income.

5.5.4. Climate Related Problems in Agriculture in Eenhana Constituency

The farmers from Eenhana constituency listed the following problems that they experience in relation to agriculture: pest outbreak, poor harvests, poor rangeland conditions, high temperature, human diseases (malaria and cholera), animal diseases, unemployment, infertile soil, deforestation, and lack of farming tools and equipment. Analyses for two problems: poor rangeland conditions and pest outbreak were conducted, as presented in Figures 9 and 10.

Results of the analysis of the poor rangeland conditions problem are presented in Figure 9. In areas where there are too many livestock, overgrazing often results, after which bush encroachment usually follows. Similarly, too many people in an area tend to build so many houses, which are often constructed in/near the grazing areas. Such situations lead to poor rangeland conditions. As populations are increasing and houses are becoming many, grazing lands are converted into crop fields, and this declines the rangeland conditions. Moreover, the changing climate creates conditions of poor rainfall, which also negatively affect the rangeland conditions. As a consequence, deaths of livestock are experienced. This affects the production of organic fertilizers for crop

fields. Additionally, poor rangeland conditions cause people to live in hunger, a condition that leads to poverty.

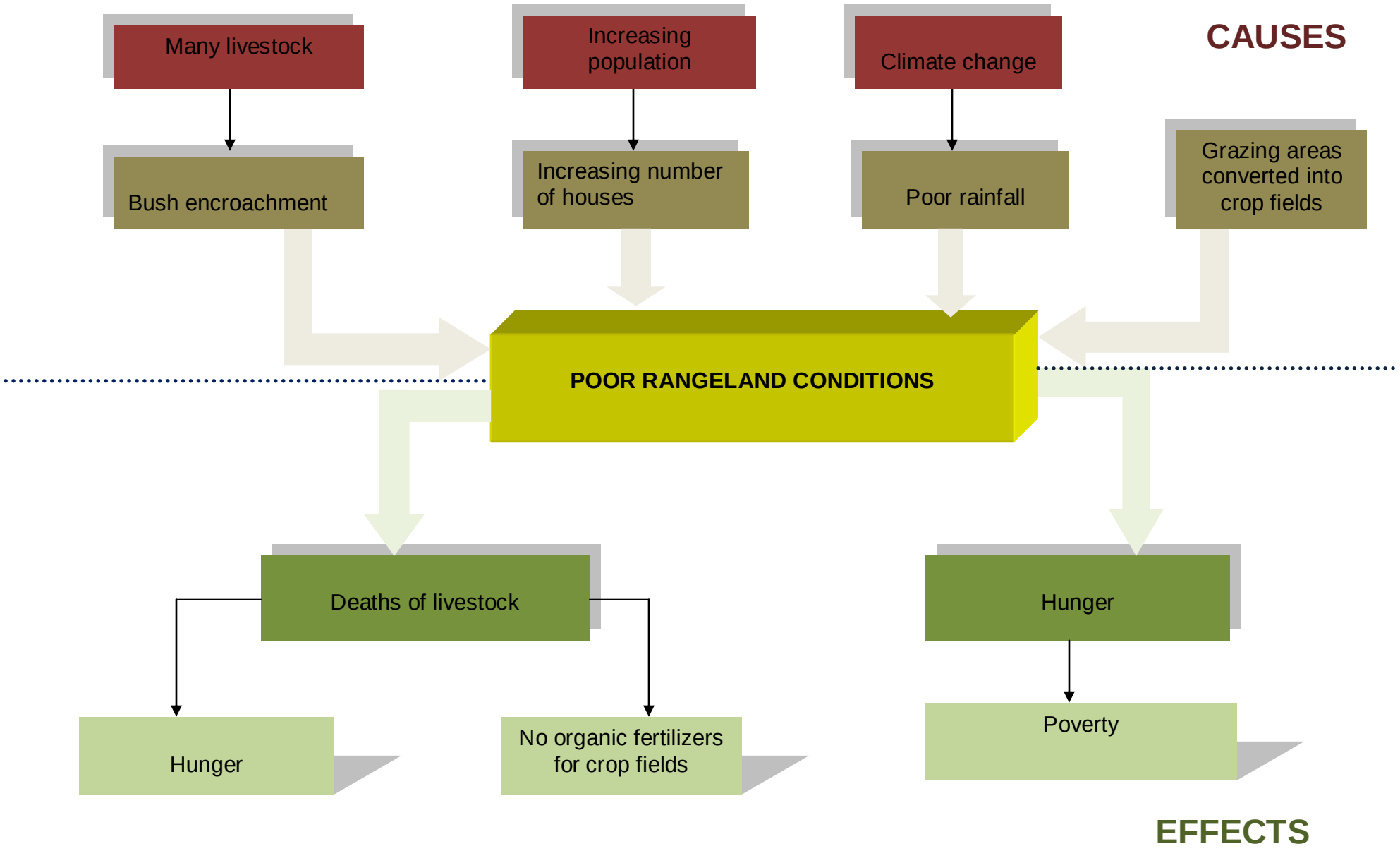

Figure 9. Causes and effects of poor rangeland conditions (views from Eenhana Constituency)

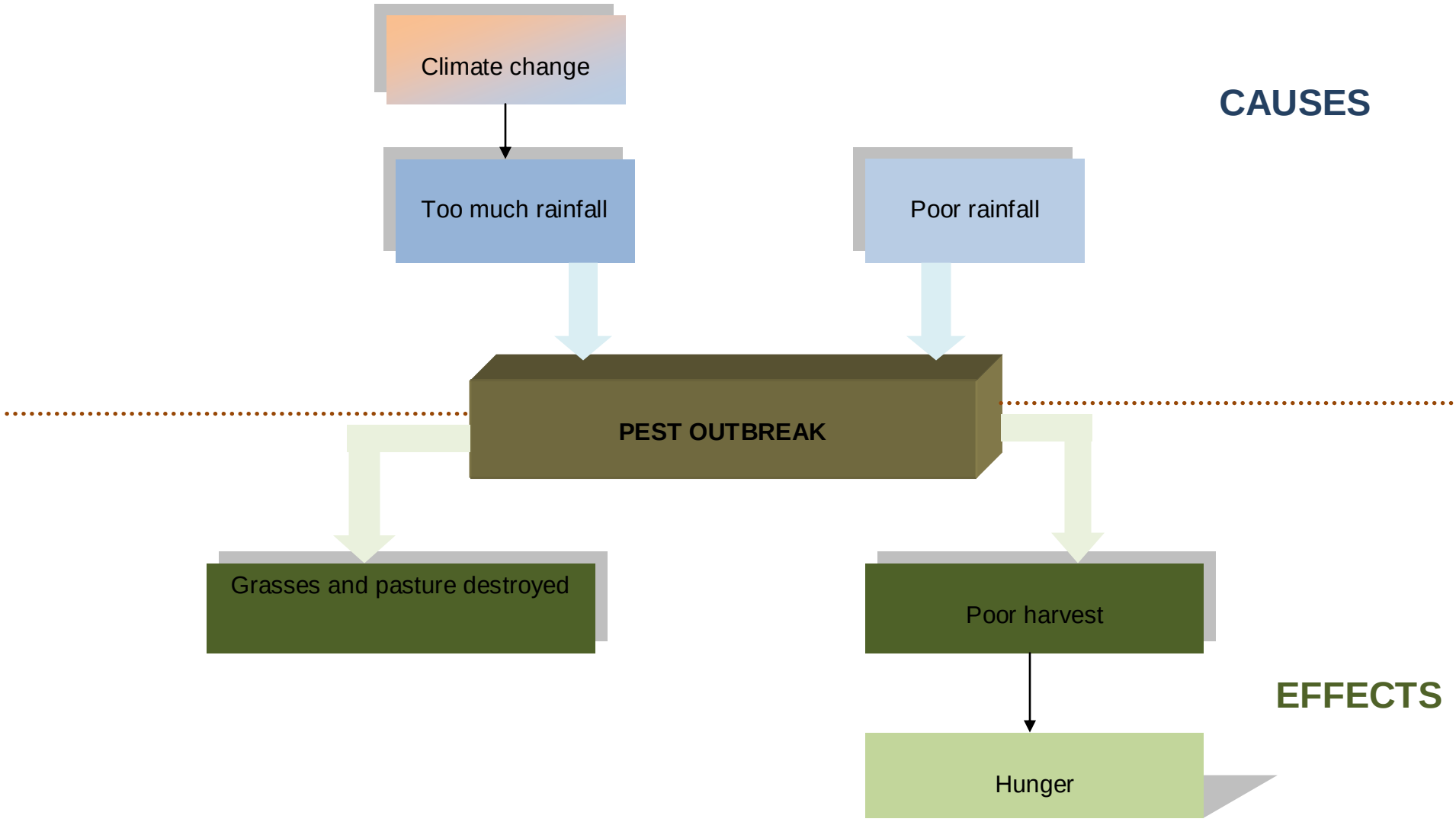

Figure 10. Causes and effects of pest outbreak (views from Eenhana Constituency)

The analysis of the causes and effects of pest outbreak is presented in Figure 10. As shown in the diagram, climate change causes too much rainfall. This creates a suitable condition for pests. Whenever the rainfall is poor, conditions also become suitable for pests. As a result of pest outbreaks, grasslands and grazing pastures are usually destroyed. Harvests also become poor during pest outbreaks, and this causes people to live in hunger.

5.5.5. Comparison of the Identified Causes and Effects of Problems Experienced in the Four Constituencies

Major problems experienced by farmers are: damage of houses by floods, pest infestations, poor rangeland conditions, inundation of crop fields, human diseases, livestock diseases, lack of drinking water, high temperature, lack of tools for farming activities, pest outbreaks, wild fruit trees dying, poor nutrient content, poor harvest, scarce natural resources, unemployment and deforestation. These have many causes and effects. Nevertheless, problem analyses were only done for some of the problems, as described below.

The problem of household damage by floods was only identified by one constituency. It is said to be caused by too much rainfall and extreme floods as a result of climate change. Strong wind is also said to contribute to household damage. As a result, people end up living in poverty, which leads to extreme poverty and hunger, while some end up building houses elsewhere or moving to other areas. It is however worthwhile to note that the issue of household damage as a result of floods has not only been experienced in Namibia, it has been experienced in other counties too, for example, Bangladesh (Thompson & Penning-Rowsell, undated), Zambia (ZVAC, 2009) and Botswana (Armah *et al*., 2010). In most cases, damage is experienced in the flood prone areas. Poorer households are said to be more vulnerable to floods (Thompson & Penning-Rowsell, undated).

Analysis of causes and effects of poor rangeland conditions has been conducted in all four constituencies, which their common problem. The views given by the farmers on the causes of poor rangeland conditions were: having many livestock contributes to

bush encroachment, which leads to poor rangeland conditions. In addition, as populations increase, people tend to place development as a priority, thus they end up developing villages into towns. This leads to poor rangeland conditions. Lack of grazing land in general also leads to poor rangeland conditions. It is also understood that traditional and cultural beliefs cause some farmers to have too many livestock. Consequently, too many livestock in an area cause overgrazing, which leads to poor rangeland conditions. Furthermore, climate change causes too much rainfall at times, which often results in too much water in an area, causing reduction in the grazing land. Deforestation is also known to contribute to climate change, which results in poor rainfall. In the absence of good rainfall, the rangeland conditions become poor. Moreover, as time goes, agricultural is becoming a priority for many people. This causes them to convert grazing areas into crop fields, which leads to poor rangeland conditions.

In general, poor rangeland conditions lead to deaths of livestock, as a result of hunger. It has also been noted that as the rangeland conditions become poor, poverty is experienced. Many crop fields also end up without organic fertilizer, because the livestock which produce fertilizer get affected by the state of rangelands. Farmers have also realized that in cases when rangelands become poor, there tends to be competition for livestock grazing space. As a result, there can be lack of peace between farmers, which leads to hatred. Poor rangeland conditions also lead to poverty.

The findings of this study suggest that there is a relationship between climate change and rangeland conditions. This agrees with a study by Yahdjan and Sala (undated), which found that rangeland productivity, is related to the variable amounts and seasonal distribution of precipitation, as well as other climatic variables.

Lack of tools for farming activities has been identified to be caused by poverty as a result of unemployment, poor rainfall, and lack of livestock. As a result people end up experiencing hunger and living in poverty. Crop fields also become infertile, and this causes poor harvests.

The farmers have indicated that cutting down of trees causes poor rainfall, and this leads to poor harvests. Generally, reduced precipitation has a negative effect on vegetation growth (Christensen *et al*., 2004). Apart from the reduced rainfall being experienced as a result of deforestation, it can also be due to climate change (Gregory *et al*., 2005). It has also been noted that whenever there are a few livestock or none at all, there is lack of organic fertilizer, hence the soils become infertile and of poor quality. This causes the harvests to be very poor. Furthermore, the changing climate causes too much rainfall, which causes farmers to harvest very poorly. This is a well known fact (Feddema, 1999; Hulme *et al*., 2000). Consequently, people end up experiencing hunger, which leads to poor health conditions and deaths. Others end up living in poverty, in the end becoming engaged in criminal activities. After all, whenever fields yield very little or not at all, the government end up offering some food relief. This was the case in the flood event of 2008 (OPM, 2008) and 2009 (FEMCO, 2009) in Namibia.

Pest outbreak is known to result during seasons of too much rainfall which the farmers attribute to climate change. Farmers also indicated that pests are also experienced when the rainfall is poor. Consequently, grasses and pastures get destroyed and the yields become poor. Therefore people end up experiencing hunger. According to Ngaira (2007), pests and food insecurity are some of the effects of climate change.

Based on the analyses conducted, climate change can be related to most of the problems (if not all) experienced by farmers with respect to agriculture and agricultural practices.

5.6. Possible adaptation strategies: proposals by respective constituencies

The representatives from the four focal constituencies were asked to propose possible solutions to the problems that were identified during the Root Cause Analysis exercise. The solutions were mainly proposed for the problems whose causes and effects were analysed. However, there was one case in which a solution to a problem that was not

critically analysed was proposed in the Endola Constituency. The results are presented in Tables 12, 13, 14 and 15.

Table 12. Possible solutions for adaptation as proposed in Endola Constituency

	Problems		
Possible solutions	**Poor rangeland conditions**	**Inundated crop fields**	**Household damaged by floods**
	• Removal of fences around the crop fields • Opting to settle in urban areas in order to secure space for cultivation and grazing • Legal protection of grazing areas • Training and provision of information on livestock farming • Training on integrated sustainable land management	• Training on cultivation methods • Relocation and resettling of people in areas which are not vulnerable to floods • Building of an earth dam	• Diversification of income • Construction of houses with cement bricks instead of clay

Table 13. Possible solutions for adaptation as proposed in Ongenga Constituency

	Problems	
Possible solutions	**Poor rangeland conditions**	**Lack of farming tools and equipment**
	• Opting to settle in urban areas to secure cultivation and grazing land • Legal protection of grazing areas • Training and provision of information on livestock farming • Selling of livestock (will help reduce livestock numbers) • Reducing of crop field sizes	• Establishment of a cooperative to buy tools for the farmers • Make use of the agricultural equipment e.g. ploughing tools (with assistance from the government) • Training on conservation agriculture

Table 14. Possible solutions for adaptation as proposed in Ondobe Constituency

	Problems	
Possible solutions	**Poor rangeland conditions**	**Poor harvests**
	• Debushing • Selling of livestock (to reduce livestock numbers) • Community-based rangeland management • Planting of grasses	• Pest management • Conservation tillage (a cultivation practice that prevents water off and washing of fertilizer away) • Gardening • Soil farming (introduction of clay soil to the fields, making use of organic fertilizers and collection of decomposed wastes to apply them across the fields) • Shift cultivation (opting to cultivate on some parts of the fields which are more productive instead of cultivating the whole fields, especially on high grounds when water levels are very high) • Improved knowledge of field cultivation

Table 15. Possible solutions for adaptation as proposed in Eenhana Constituency

	Problems	
Possible solutions	**Pest outbreak**	**Poor rangeland conditions**
	• Training on pest management • Research on the causes of pest outbreak • Diversification of income	• Training on livestock management • Integrated sustainable land management • Establishment of community-based livestock management

Overall, the proposed solutions in all constituencies were summarized. These could be considered as the future adaptation measures. In order for farmers to be able to adapt to conditions related to the problems identified during the problem analysis exercise, adaptation strategies need to be in place. Adaptation is important, as it aims to reduce vulnerability and to improve people's capacities, particularly those who depend on agriculture for livelihood (IECN, 2008). According to Adger *et al*. (2003), all societies need to enhance their adaptive capacities in order to be able to face both the present and future climate change outside their experienced coping range. By definition, adaptive capacity is the ability of a system to adjust to actual or expected climate stress or cope with consequences (O'Brien *et al*., 2004 in Boardley & Schulze, 2005). Schipper (2007) has indicated that an adaptation process can succeed if it will require addressing the underlying causes of vulnerability adequately.

Generally, many adaptation options exist, which can reduce the negative impacts of climate change in the livelihoods. They however need to be carefully planned and implemented, in order to address both for short and long term impacts of climate change (Schipper *et al*., 2008).

A number of adaptation options which could potentially be implemented in order to reduce the risks associated with climate change and variability within the region have been recommended. This is due to the fact that the risks associated with climate change are known to exacerbate ongoing social challenges, especially in societies that depend on resources that are sensitive to climate change (Adger *et al*., 2003).

The adaptation options that can be implemented by farmers to address the impacts of climatic events on agriculture are presented in Table 16.

Table 16. Adaptation options that could be implemented to address the impacts of climate change in Ohangwena Region

Proposed strategy	Description and relevance
Rehabilitation of degraded rangelands	This is a potential strategy that requires an understanding of interferences which the rangeland ecosystems can tolerate without suffering irreversible degradation. Placing it into practice will help improve the penetration and storage of rainwater and enhance biomass production. Such a strategy should be based on sound ecological and integrated management of natural resources. Rehabilitation of rangelands should therefore be implemented along with actions such as controlled grazing and use of livestock manure to fertilize the land. Ultimately, degradation of the restored land will no longer result.
De-bushing	This entails the removal of uncontrolled encroaching bushes. It has a potential of increasing productivity of the land. Therefore in areas where there is only bush and no grass left, de-bushing can be considered as a strategy for improving grazing capacity.

Crop diversification	Farmers can adapt to climate change by switching crop varieties (Kurukulasuriya & Mendelsohn, 2006). This means climate sensitive crops can be avoided during unfavourable climates. Crop choices, for example, drought resistant and fast growing crops such as Okashana and Kangara (millet species) can survive even in dry conditions. They tend to mature before soil moisture depletes. Maize can for example be an option when conditions are wet (Kurukulasuriya & Mendelsohn, 2006).
Cropping pattern adjustments	Adjustments on cropping patterns can be an option for adaptation to overcome the adverse impacts of higher temperature and changing precipitation pattern. In this strategy, crops can be planted further apart so that there could be more available moisture for each row. Such a practice will help crops to survive a period of drought. Other types of intensively managed agricultural systems such as crop rotation and intercropping could also be practiced. These may however require availability of resources such

	as fertilizer and financial resources (Adams *et al*., 1998).
Rainwater harvesting	Refers to the collection and utilization of rainwater for domestic and agricultural purposes. Rainwater harvesting can be used as an adaptation strategy when water becomes a scarce resource. This strategy does not require capital investment; however, any dependable water harvesting system requires regular maintenance.
Conservation agriculture	This is an application of modern agricultural technologies to improve production while at the same time protecting and enhancing the land resources on which production depends (Dumanski *et al*., 2006). It reduces vulnerability to extreme climatic events, for example, reducing crop water requirements during drought conditions and facilitating rainwater infiltration during wet conditions. Through conservation agriculture, sustainable agricultural production and environmental conservation can be achieved. Most importantly, it provides opportunities to farmers to improve their livelihoods.

Small scale gardening	Gardening on small scales can be used as an option to adapt to extreme conditions. Through small scale gardening, the diets of communal farmers can be diversified. In addition, they have a potential to reduce high dependence on mahangu for food through increasing food security.
Early warning systems and improved climate information	Systems can be designed to provide early warnings regarding changing weather conditions. Such systems can measure parameters such as rainfall, temperatures, water levels, weather forecasts, and can identify conditions of extreme drought. With early warning systems in place, farmers can be forewarned and instructed before the conditions become extreme (OPM, 2008). They can also be provided with reliable information related to changing climate patterns. The threatened farmers can then take appropriate actions in a timely manner. Some of the systems don't have to be advanced. Farmers can for example make decisions based on indicators such as, appearance of some plants, immature dropping off of fruits, and appearance or absence of certain animals or insects.

Pest management	This is an approach to managing the destructive insects, birds and weeds. Pest management can be made possible through investing into integrated weed and pest management, and improved veterinary services. With such a system in place, increase in crop yields should be expected.
Pest management	This is an approach to managing the destructive insects, birds and weeds. Pest management can be made possible through investing into integrated weed and pest management, and improved veterinary services. With such a system in place, increase in crop yields should be expected.
Rural-urban migration	Refers to the movement of people from rural to urban areas. In this way, rural population and pressure on rural areas can be reduced.
Herd management	It can be used as a management tool to improve the rangeland conditions and herd diversities. This can be made possible by maintaining the female-dominated herds, herd sizes and by splitting herds.
Livestock feed supplementation	Aiding livestock feeding with supplements can contribute to

	effective livestock farming. Using fodder plants and certain tree species as supplements can increase livestock energy and milk production.
Access to markets	Farmers need to be able to take their products to markets and make benefits from them. Through establishing marketing and trading cooperatives, the farmers will be allowed to make some profit.
Agro-forestry management	This is a potential adaptation strategy against severe impacts of climate on plants and animals. Once practiced, it can improve and diversify crop production. Agro-forestry management can contribute to improved retention of soil water moisture through intercropping and agroforestry. Trees can be planted and used as alternatives sources of food supply especially during extreme conditions, as they can provide natural products. Fodder plants can be used as supplements for livestock, particularly when food availability becomes a challenge.
Management of livestock diseases	Lives of livestock can be threatened by diseases. Through effective management of diseases, the health of livestock can be secured. This can be made possible through provision of education on disease management methods,

	as well as through increased veterinary assistance. As part of management, farmers can make use of preventive measures, for example, keeping away from areas known to be vulnerable to diseases.
Diversification of livelihoods	This refers to adding new activities to those already existing. Farmers can diversify livelihoods from income generation activities such as cultural tourism and small business enterprises. Such an approach is necessary, particularly because crop fields can be vulnerable to the extreme events of climate variability. In order to improve the household incomes and build their adaptive capacities to the adverse effects of climate changes, farmers can promote the income generation activities as well as the development of mutual benefit societies.

It is worthwhile to note that not all adaptation strategies may be applicable to all areas. Therefore identifying adaptation strategies should be selected based on their applicability, and for the purpose of ensuring sustainable livelihoods and improved food security in the face of the changing climate. Nevertheless, communities need to make right choices based on their applicability to their areas and conditions. Furthermore, they need to be well informed or educated by knowledgeable people, for example, researchers, on climate change related issues. This will help build their capability to be adaptive (Tompkins & Adger, 2005). Communities also need to be encouraged now and then, and be empowered to make decisions regarding the adaptation measures that could be implemented within their respective areas.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1. Introduction

The major findings and conclusion of this are presented in this chapter. It has aligned the findings with the research objectives, and has attempted to answer the research questions.

There is sufficient evidence to prove the reality of climate variability in Namibia. Extreme weather events of floods and droughts are the main results of climate variability in northern Namibia. Variability in climate patterns mainly results in affected rainfall patterns, and in increasing atmospheric temperature. Such changes are attributed to natural factors such as the ENSO factor; however they can also be induced by human activities.

The findings of this study agree with the results by Olzewski (2010) that rainfall in the focal areas of this study falls between the late months of the year (September – December) and the early months of the year (January – April). However, the amount of rainfall received varies between seasons. High amount of rainfall is more received during the early months of the year compared to the amount received during the late months of the year. Apart from the observed variability in rainfall patterns, temperature increases have been observed over the years. In fact, temperatures have become hotter than before.

This study has paid more attention to the impacts of floods then those of drought. In the absence of early warning systems for floods, farmers are never prepared for flood events, thus they experience adverse impacts. Noteworthy, many houses in Ohangwena Region are situated in flood prone areas. The major impacts of floods are mainly: destruction of crop fields, livestock losses, destruction of households, loss of infrastructure, pest outbreaks, reduced soil fertility, reduction of crop yields, destruction of crop fields, poor rangeland conditions, diseases and loss of human and animal lives.

Agriculture is the major source of livelihood in northern Namibia; however, it is vulnerable to climate sensitivity. As a result, rural people's livelihoods get affected, particularly because the resource availability and food security is often affected. The fact that communities in Ohangwena Region depend on agriculture for livelihoods makes them vulnerable to climate change. Dependence on agricultural products alone for survival is a risk, particularly because farmers can have either poor harvests or no harvests at all. Socio-economic factors such as poverty and unemployment contribute to their vulnerability. In essence, household incomes in Ohangwena Region are very low; which would have been an alternative source of livelihood. Consequently, people end up experiencing hunger and poverty. In reality, communities cannot address the impacts of climate variability on their own; therefore in situations when they are hardest hit by the climatic events, they receive food relief from the government, various institutions and organizations, businesses and groups. Apart from the food relief, they also receive other forms of support such as shelter, medical support and the basic essentials.

In the absence of adaptation strategies, both short- and long-term, impacts of floods cannot be addressed. However, more flood events are likely to be experienced in the long-term. At the moment, the adaptive capacity in the region is very weak; therefore developing adaptation strategies is the best option. As per finding by Dirkx *et al*. (2008), vulnerability to climate change can be due to lack of coping mechanisms. This study has found that the coping strategies currently being implemented in Ohangwena Region are very weak, therefore they need to be strengthened in order for the farmers to be able to cope with challenges associated with climate variability in future. However, possible future adaptation strategies have been proposed. Many farmers understand their local problems and have in mind some sorts of solutions to the problems; however, they need support from the government to address such problems. In such a way, effective long-term adaptation strategies can be maintained.

6.2. Lessons Learned

The rainy season that supports crop cultivation no longer starts in September or October as it used to happen in the past. It has lately been starting in January and February. As a result, time for cultivating fields is delayed due to delayed rainfall; thus poor yields are often experienced. Noteworthy, farmers do not only depend entirely on agricultural products for food, they also supplement their diets with natural products. These are however only available during certain periods of the year.

High levels of water are experienced mainly due to floods and heavy rainfall. Floods in many parts of Ohangwena Region are due to overflow of rivers in Angola after heavy rainfall.

The flood prone areas are more at risk of flood impacts. Consequently, severely impacted farmers opt to move to high grounds in order for them to cope with high concentrations of water. This usually happens after the houses have already been flooded, particularly because there are no early warning systems to assist them to be well informed and be forewarned before the households become flooded. Nevertheless, there are currently no coping strategies for inundated crop fields.

The adaptive capacity for communities in Ohangwena Region is currently weak and it needs to be strengthened. This can be made possible by developing and implementing adaptation strategies for climate variability and change in Ohangwena Region. Noteworthy, a wide range of stakeholders can contribute to the strengthening of the adaptive capacity within the region. Training on climate issues can also contribute to increased adaptive capacity.

Despite the fact that many adaptation strategies exist for agriculture, not all of them are applicable in all constituencies. Therefore they need to be wisely selected. Nevertheless, incorporating climate variability and change into adaptation measures to reduce vulnerability is essential in order for them to be sustainable wherever they are applicable (Yohe *et al*., 2007)

6.3. Recommendations

6.3.1. Implementation of Adaptation Strategies

The fact that communities in Ohangwena Region suffer the consequences of climate variability cannot be ignored. For this reason, the proposed adaptation strategies in Section 5.6 should be implemented. These are long-term interventions to respond to impacts of climate variability on the agricultural practices and products. Generally, adaptation strategies require an integrated approach, capacity for both short- and long-term planning, and an enabling policy framework which should reinforce actions at regional and national levels (Schipper *et al*., 2008). Therefore they need to be included in the national development plans. Due to the fact that communities cannot implement the strategies in their current capacities, all relevant stakeholders need to be involved in supporting the vulnerable communities to implement them. Stakeholders include: agricultural researchers, national experts, policy makers, development planners, the University of Namibia (UNAM), Polytechnic of Namibia (PoN), Ogongo Agricultural College and Neudam Agricultural College. The stakeholders should make it a point that they share their knowledge with communities at the regional and local level, particularly with regional leaders who are involved in making decisions on the ground (Huq, 2002). This will contribute to effective implementation of the adaptation strategies. Adaptation strategies will also require communities to be willing to make adjustments with regard to new environments, to adopt appropriate technologies and to make best use of traditional knowledge in order to address the long-term climate change impacts. Essentially, an implementation plan must be in place, which should include the following: tasks of priority, timelines for implementing them, roles of stakeholders/implementing partners and resources required (USAID, 2007). Most importantly, the plan should include the component of capacity building needs assessment, a financial plan indicating the funds required and possible opportunities for funding, a communication plan, a sustainability plan and a monitoring and evaluation plan.

6.3.2. Development of an Outreach Programme on Climate Change

Communities should be made understand that the extreme events of floods and drought are a result of climate variability, which occur both naturally and can be induced by human activities. It is essential that communities should be made environmentally aware that climate change is real and is a problem; however, people need to do their part to secure their future. This can be made possible by developing an outreach programme aiming at raising awareness about the changing climate and issues associated with it. Such a programme can be facilitated by people with some knowledge on climate issues, people willing to perform a number of activities geared towards fostering a positive community experience. Through this programme, information materials such as flyers and posters can be developed and shared with communities within the region, community meetings can be held to discuss issues around climate change, and programme facilitators can make use of radio as a platform to inform people about the reality of climate change and let them know the sorts of activities that they should avoid doing which contribute to climate change, for example, cutting down of trees. Communities can also be informed about the possible adaptation strategies for the changing environment through this programme. A proposal for this programme highlighting the envisaged activities, timelines and budget needs to be developed with support of regional leaders, and should be submitted to stakeholders for input as well as to potential donors in order for it to be implementable.

6.3.3. Avoidance of Flood Prone Areas

After the events of floods recently experienced, it has become evident that communities in flood prone areas are more vulnerable to floods compared to those whose households are located on high grounds. It is likely that more floods will take place in future; therefore prospective farmers should avoid settling in low lying areas. In addition, farmers that are currently located in flood prone areas should consider moving their houses to high grounds instead of waiting for their houses to be flooded before they can move. Regional leaders and village heads should therefore keep the community people informed of possible places where they can build houses, which are less vulnerable to

floods. Furthermore, regional leaders should seek support from relevant government institutions with mapping of the region, as it can help them be knowledgeable of the most vulnerable and the less vulnerable areas (OPM, 2008). When necessary, they should also look for potential funding to support communities with relocation. Overall, regional leaders should maintain communication with the relevant stakeholders, as well as with the community members.

6.4. Conclusion

The existing adaptation measures within the Ohangwena Region have been explored and analysed. The climate patterns in Ohangwena Region have been assessed. Impacts of floods on agriculture within the region have been assessed. Coping strategies have been identified. Lessons learned from the pilot constituencies have been documented, and recommendations on possible adaptation strategies have been made. Henceforth, with the knowledge on existing adaptation and coping strategies in the region, and with the recommended adaptation strategies, regional capacity to adapt to climate change can be enhanced.

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ANNEXES

Annex 1: Questions posed during the first focal group discussion session

1. Have you noticed any change in climate over the past years?
2. What causes floods?
3. Are the floods caused by rainwater or water flowing from Angola?
4. Have you experienced heavy floods before in the past?
5. How do crop fields get affected by floods and droughts?
6. Do you experience any pest infestations during floods?
7. Are there some areas which do not experience crop losses?
8. Do you sell crops?
9. How do the livestock get affected by floods?
10. What other problems do you experience during floods and droughts in relation to agriculture and farming?
11. Which of the two is mostly affected by floods and droughts? Livestock or crops?
12. What strategies do you use when the fields are inundated?
13. Do you relocate during floods? If so, where to? How long for instance?
14. Do you get any compensation for the losses?
15. What kind of help would you need for future survival?