THE EFFECTS OF CLIMATE CHANGE ON HOUSEHOLD FOOD PRODUCTION IN RURAL MAKHADO LOCAL MUNICIPALITY, LIMPOPO PROVINCE

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THESIS

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DECLARATION

I Thanyani Selby Madzivhandila declare that the thesis hereby submitted to the University of Limpopo, for the degree Doctor of Administration in Development Planning and Management has not previously been submitted by me for a degree at this or any other University; that is my work in design and execution, and that all the materials contained herein have been duly acknowledged.

_____ _____

Initials & Surname (Title) **Date**

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DEDICATION

This study is dedicated to my father the late Mr MJ Madzivhandila. I know that if you were still with us you would have been proud of what I have achieved. The study is also dedicated to my mother Mavis Munyai and grandmother Vho-Nyawasedza for being there for me when I needed them most. The study is also dedicated to my spouse Zanele and our children Phomello and Vhutali Madzivhandila for encouraging me to work harder in order to achieve the best in life. Thank you and I love you unconditionally.

ABSTRACT

The thesis of this study is that food production systems for self-provisioning have historically constituted the backbone for survival and life-support in rural South Africa. Colonialism and apartheid capitalism bore harsh effects on the food production life-support systems. However, these effects pale into insignificance compared to the present devastation of the food production systems associated with climate change. The contribution of rural South Africa towards climate change is at all scale negligible because poor people hold limited capacity to produce the deleterious gas emissions that allegedly causes global warming. However, the poor are disproportionately exposed to the adversarial effects of climate change and their food production systems have demonstrated beyond doubt that they cannot cope with stressors occasioned by climate change. Government policy and measures continue to be inadequate and inaccessible for rural households that produce for self-provisioning.

The thesis further demonstrate that scientifically–based intervention measures adopted among rural poor in developing countries are viewed as alien and therefore not wholeheartedly adhered to by the users. The thesis points to this discrepancy to illustrate that the value systems among the rural population in South Africa describe changes in their food production in terms of climatic conditions that are, according to their belief systems, avoidable consequences of people's conduct of life outside tradition, religion and so on. It engages a nascent argument relating to the failure of private and public scientifically-generated intervention measures within developing countries' rurality, which is ironically exacerbated by the apparent inappropriateness and, often, destructiveness

of the Green Revolution Technologies. As such interventions fail, the thesis points, they create skeletons of evidence, that appear to corroborate the traditionalist belief systems about the locus of causes of change in climatic conditions being extra-terrestrial as a consequence of people's misconduct of life.

The study investigates the effects of climate change on household food production systems in rural Makhado Local Municipality. 30 villages are used for this study in both households questionnaire survey, interview of the key informants and observation of different patterns of production process, geo-spatial features and current settlements patterns. The data analysis results reflect that different households within the municipality experiences variety of effects of climate change. Furthermore, the climatic conditions which consisted of enough reliable precipitation during food production stages have declined; rather in the post-1990 period, the area have been experiencing continuous heatwaves and drought which destroyed household's crops and livestock. Using the normative and historical research designs the study found that the situation within villages has changed drastically because of climate change when comparing the conditions pre- and post-1990. The deliberate adoption of the historical design was crucial given that the thesis mission was to highlight the discrepancies in the so-called modern systems versus the traditionalist philosophies that continue to dominate the thinking and action rural populations in most developing countries. Equally, the historical design provides unquestionable possibility of applying appropriate research techniques to contextualize the research problem under investigation. Indeed, this manoeuvre has always been an important part and parcel of the research design and methodology because the thesis

had to adopt a longitudinal research orientation through an appropriately designed data collection tool, specifically the questionnaire and interview schedule. From a philosophical perspective, the thesis demystifies the thinking that the so-called scientifically-generated interventions against climate change could resolve the attendant challenges, inclusive of food production. That is, it insinuates that appropriate research is needed for developing countries rurality in order to find intervention measures that are a product of the evolution of traditionalist value systems. Tacitly, the thesis challenges the statist and private sector habits of always parachuting the so-called scientifically-generated solutions to climate change.

ACRONYMS

AIDS: Acquired Immune Deficiency Syndrome

CDM: Clean Development Mechanism

Cop 3/17: Conference of the parties

DEAT: Department of Environmental Affairs and Tourism

ECM: European Countryside Movement

EPA: Environmental Protection Agency

FAO: Food and Agriculture Organisation

GCOS: Global Climate Observing System

GDP: Gross Domestic Product

GHG: Green House Gas

GHS: General Household Survey

HIV: Human Immunodeficiency Virus

IFAD: International Fund for Agricultural Development

IFPRI: International Food Policy Research Institute

IPCC: Intergovernmental Panel on Climate Change

ISS: Institute for Security Studies

MDGs: Millennium Development Goals

MLM: Makhado Local Municipality

NDP: National Development Plan

NGO's: Non-Governmental Organizations

NOAA: National Oceanic and Atmospheric Administration

Stats SA: Statistics South Africa

UNFCCC: United Nations Framework Convention on Climate Change

UN: United Nations

US: United State

WMO: World Meteorological Organization

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CHAPTER 1

INTRODUCTION AND BACKGROUND OF THE STUDY

1.1. Introduction and Background

The ongoing universal hyperbole holds that of all environmental problems that have emerged in the past few decades, climate change is the most serious and difficult to manage. Importantly, climate change is understood to be threatening not only the sustainable development of socio-economic and agricultural activities of most nations, but the totality of human existence (Adejuwon, 2004; Barnett & Adger, 2007; Osbahr, Twyman, Adger, Thomas, 2008; Jones & Thornton, 2009; Ayinde, Ajewole, Ogunlade & Adewumi, 2010). Through its diverse manifestations such as flood and drought, climate change has implied that the local climate variability that people previously experienced and adapted to have changed (Olesen & Bindi, 2002; Adejuwon, 2004; Ayinde et al., 2010). However, as Ayinde et al. (2010) put it, the existence and spread of climate change is widely debated amongst natural scientists, especially with regard to the contestations of its impacts. One of the most striking aspects of the debate is the intensity of the disagreement expressed over what might be expected to be a simple matter of scientific fact, whether the earth is warming-up and whether human emissions are responsible. On one hand, 'sceptics' say that the earth is not warming-up to the extent that it could be called a crisis; in fact, some 'scientists' even suggest that the earth is getting colder whilst, on the other hand, others stress that climate change is bearing detrimental effects not only on the environment, but also on the entire ecological system (Totty, 2009).

The current evidence of high temperatures, rising sea levels, low rainfall, drought, floods and acid rain amongst others, are scientifically linked to the existence of climate change (Olesen & Bindi, 2002; Adejuwon, 2004). Evidently, in recent years most agriculture-dependent countries have not been able to produce enough food (Barnett & Adger, 2007). Allegedly, the production systems of such countries have been subjected to unprecedented adverse climatic conditions. The most affected particularly in the third-world countries are the vulnerable groups of poor households in rural areas because their alternative sources of food, beyond own production, are severely limited (Barnett & Adger, 2007; Barnett, Dessai & Jones, 2007). In most of African states for instance, subsistence agriculture is at the centre of rural households' food security systems. Moreover, warming and drying, which is propelled by climate change, reduces households crop yield and degrades grazing land for livestock, thereby compromising poor people's efforts to strengthen food security (Osbahr et al., 2008). The assumption underlying these current and future scenarios is in line with the argument of this study, which holds that the effects of climate change could be severe on food production systems of poor households in rural areas. The long and short term negative effects of climate change could depend on the present soil conditions, the severity of the change as well as the availability of resources and infrastructure designed for coping with the change (Olesen & Bindi, 2002). The increasing frequencies of heat stress, drought and flooding events have undoubtedly produced adverse effects on food production in most of African countries (Osbahr et al., 2008; Jones & Thornton, 2009). Furthermore, Osbahr et al. (2008) predict that in Africa warming is expected to be greater than the global average and in most parts of the continent rainfall will decline, posing a great

threat to not only food production but also to water security, public heath, natural resources and biodiversity.

In its National Climate Change Response Strategy, South Africa's Department of Environmental Affairs (2004) mentioned climate change as one of the greatest environmental challenges facing the country. The strategy states that climate change does not only have an influence on increasing temperature, but it is a phenomenon that disrupts the entire weather and climate patterns with extreme impact on rainfall, weather events and rising in sea levels. Coincidentally, statistical evidence in South Africa suggest that the country has been getting hotter over the past four decades, recording more warmer, than cooler, days (Hassan, 2006). As a responsible global citizen with moral as well as legal obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, South Africa is committed to contribute a fair share to the global greenhouse gas mitigation efforts (Department of Environmental Affairs, 2011). Efforts of the South African government are in line with the objectives of the Kyoto Protocol which was adopted at a meeting of the UNFCCC in Kyoto, Japan in December 1997. The Kyoto Protocol sets binding targets for industrialized countries to reduce their combined greenhouses gas emissions by at least 5% compared to 1990 levels in the period 2008 to 2012 (Department of Environmental Affairs, 2011). This legally binding commitment promised to produce a historical reversal of the upward trend in emissions that started in these countries some 150 years ago (Department of Environmental Affairs, 2011). South Africa is classified as a developing country in terms of the convention and was not obliged to adhere to the

more demanding commitments placed on developed countries to the convention (Hassan, 2006; Department of Environmental Affairs, 2011). However, South Africa's efforts to curb the effects of climate change are driven from the notion that global greenhouse gas reduction efforts must work in cycle, with a pro-poor adaptation agenda (Department of Environmental Affairs, 2011). It is hoped that such an approach will empower the poor and vulnerable and ensure human dignity, whilst endeavouring to attain environmental, social and economic sustainability.

Indeed, changing climatic conditions affect agricultural practices since they are highly dependent on climatic conditions and variables such as temperature and precipitation (Hassan, 2006). Besides, South Africa's semi-arid dry land crop farming and livestock rearing for food production in rural areas accentuate their household vulnerability to climate change by marginalizing efforts to secure food. Furthermore, the commitment to tackle issues of climate change by the South African government was evident when it hosted the Conference of the Parties (Cop17) in 2011. As a signatory to the UNFCCC, South Africa hosted the Conference from 28 November to 9 December 2011 in Durban. The outcomes of the conference include among other things the commitment by both developed and developing countries to compile a new international agreement to reduce greenhouse gas emissions which will come into effect in 2020 and the endorsement of the Green Climate Fund to assist developing countries' transition to a low carbon economy (Hassan, 2006; Department of Environmental Affairs, 2011).

South Africa is still firm on the fight against the effects of climate change even though facing huge challenges (Hassan, 2006; Stats SA, 2007; Department of Environmental Affairs, 2011). Rural households in Limpopo Province, one of the poorest provinces in South Africa, continue to experience some socio-economic hardships and poverty that are inextricably linked to the changing climatic conditions (Statistics South Africa (Stats SA), 2007). Over 70% of poor households in the province practice subsistence agriculture, which includes crop and livestock farming, to secure food. Given these rural households' lack of access to agricultural resources such as irrigation, their food production practices are fully depended on precipitation (Stats SA, 2007). Rain-fed food production activities among the poor households are inherently sensitive to climatic conditions of higher and fluctuating temperature as well as changing precipitation patterns and levels (Stats SA, 2007). These conditions derail the efforts of households in regard to securing food through their subsistence agricultural practices (Stats SA, 2007; Department of Environmental Affairs, 2011). One of the poorest municipalities in Limpopo Province, Makhado Local Municipality is characterised by the majority of poor households that are practicing crop and livestock farming as an important part of household food production. The municipality is predominantly rural with about 86% of its population living in rural areas, engaged in subsistence agriculture for food self-provisioning (Stats SA, 2007). This study uses Makhado Local Municipality to investigate the effects of climate change on food production among rural households.

1.2. **Statement of the Research Problem**

Climate change has been identified as a 21st century world-wide concern, with disproportionate effects on the third world countries, especially those in Africa (Barnett & Adger, 2007). Poor people in developing countries live in close contact with nature, with the result that fluctuations in natural circumstances create stressors of their life support systems such as food production (Adam, 2001). However, the nature of the relationship between climate change and a variety of other variables remain unresolved; equally, determinants and manifestations of climate change are still a matter of international debate and conjecture (Olesen & Bindi, 2002; Barnett & Adger, 2007; Ericksen, Ingram & Liverman, 2009). According to Olesen & Bindi (2002), the extent to which people depend on natural resources is intricately interlocked with their degree of vulnerability to climate change. Inevitably, extreme meteorological events such as spells of high temperatures, heavy storms, drought and floods, which are the most notable results of climate change bear disproportionate effects on the poor people's life support systems (Ericksen et al., 2009). Poor rural households' food production systems are heavily dependent on the conditions of natural resources such as land and water, whose availability and quality is now linked to the adversarial effects of climate change. As a result, poor people's life support systems are increasingly facing pressure of the stressors that are linked to global climate change. Of all the life support systems, food production is the most vulnerable for poor rural households because food security has consistently been a challenge, even under normal circumstances (Barnett & Adger, 2007). Thus, poor rural households have been the most vulnerable to climate change,

years prior to formal recognition of the nascent climatic conditions (Barnett & Adger, 2007), largely because of the intricateness of their survival with nature.

Statistical evidence suggests that South Africa has been getting hotter over the past four decades (Hassan, 2006). In general, the country has been approximately 2% hotter and at least 6% drier over the past 13 years between 1997 and 2009 (Blignaut, Ueckermann & Aronson, 2009). The average yearly temperature is estimated to increase by 0.13ºC per decade (Hassan, 2006). Based on the Hassan (2006) projections, it is concluded that South Africa too is experiencing climate change and its manifestations. Given the depth and severity of rural poverty in South Africa, the prevalent climate change can be expected to have borne adversarial effects on poor households' food production systems. Therefore, climate change undermines South Africa's efforts to alleviate poverty and to provide for food security, clean water, energy supply, environmental health and human settlement (Department of Environmental Affairs, 2004). To this extent, rural South Africa's household–food production systems are adjudged to be moderately successful (Baiphethi & Jacobs, 2009), justifying the assertion that the changing climatic conditions destabilize households' efforts to secure adequate food for survival. About 35% of the South African population are recorded to be vulnerable to food insecurity and such trend has proved not to be a short-term event but a continuous threat to communities, particularly in rural areas (Van Averbeke & Khosa, 2007). This situation is exacerbated by the fact that the climate-soil combination had left only 12% of the land suitable for the production of rain-fed crops, with only 3% considered to be fertile (Department of Agriculture, 2006). Limpopo Province is

predominantly rural, characterised by the majority of poor households practicing subsistence farming as a household food production system. The effects of climate changes are evident in the province; hence, the manifestations of climate change through for example, drought, heatwaves and floods have been visible over the years. The study examines the effects of climate change on food production using Makhado Local Municipality as a case wherefrom practical evidence was solicited.

1.3. Research Questions

The study formulates the general research question as follows: How does climate change affect rural households' food production? Specific research questions are formulated from the general research question as follows:

- What are the determinants and indicators of climate change?
- How do rural households produce food (crops and livestock)?
- What are the environmental challenges facing rural households' food production?
- What are the effects of climate change on rural households' food production?

1.4. Research Aim and Objectives

The study aims to investigate the effects of climate change on rural households' food production. To unpack this aim, the proposed study formulates the specific objectives as follows:

- To study the determinants and indicators of climate change;

- To examine rural households' food (crops and livestock) production systems;
- To assess the environmental challenges facing rural households' food production;
- To uncover the effects of climate change on rural households' food production ;
- To recommend measures that could minimise the adversarial effects of climate change on rural households' food production.

1.5. Definition of Terms

Climate Change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years (Fraser, 2006). It may be a change in average weather conditions, or in the distribution of weather around the average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors that include oceanic processes, variations in solar radiation received by Earth, plate tectonics and volcanic eruptions, and it can also be attributed directly or indirectly to human activities that alter the composition of global atmosphere and that is in addition to natural variable, observed over comparable time (Ericksen et al., 2009). The determinants of climate change are linked to the increasing concentration of carbon dioxide in the atmosphere and they have causal connections to rising sea levels, El Nino, La Nina, hurricanes, floods, drought and acid rain amongst others (Ericksen et al., 2009). Thus, the latter occurrences are accepted as observable and/or measurable manifestations of climate change. The study adopts this definition as it encompasses climate change determinates and its manifestations.

Household Food Production includes the cultivation and tillage of soil and livestock rearing by a domestic unit consisting of the members of a family who live together along with nonrelatives such as servants in order to produce food such as maize and vegetable. Household Food production, particularly in rural areas, is central for accessing food among rural communities. In rural area this process is mainly characterised by subsistence farming, which means households engage in crop production, livestock rearing and associated activities mainly for own consumption (Baiphethi & Jacobs, 2009). These activities are usually associated with low productivity, risk and uncertainty (Baiphethi & Jacobs, 2009). The production systems in rural areas are vulnerable to climate change variation. The study adopts this definition since it illustrates the process of food production in a rural area context.

1.6. Research Design and Methodology

There exist substantive research that applies a variety of combinations of different research designs and methodologies in the study of the relationship between climate change and food production (Fraser, 2006). For instance, Reddy & Assenza (2009) and Whitmarsh (2011) applied research designs and methods that are qualitative in the analyses of the debate, and the dimensions and determinants of climate change, respectively. Quantitative schemes and methods have equally been shown to be applicable as evidenced in Tingem et al. (2009) investigation of crop production response and adaptation to climate change, as well as that by Simelton et al. (2009) on typologies of crop-drought and attendant socio-economic factors. These and other such studies have demonstrated that a combination of qualitative and quantitative aspects of

different designs and methods is most appropriate for the investigation of the effects of climate change on food production, which is the focus of this study. The discussion below details the plan, structure and methods that is applied for the study.

1.6.1. Research Design

The dependent variables to be studied in the effects of climate change on food production, such as emissions of greenhouse gases, global warming, drought, unseasonable precipitation patterns and so on are beyond the capacity of the study's control. Inevitably, the research design most suitable is normative evaluation wherein events and processes are observed and assessed. Given that climate change and food production happen over time, a cross-sectional investigation of their present interactions would remain incomplete without a historical context. For this reason, the study embraces a historical dimension in a longitudinal analysis to trace the manifestations of the factors under investigation and their association through periodization following the post-Second World War. The study assessed the events of climate change and food production pre and post the period the year 1990. The variation in temperatures, precipitation and food production systems are closely studied to determine climate change and its effect on food production

Using normative longitudinal and historical research designs, the study evaluated different events and processes associated with the systems and processes of climate change, environmental patterns and challenges to food production. Also, the study

assessed changes in crops and livestock that households have produced over time. To this extent, the study adopted desktop review in order to evaluate textual data on debates, determinants and manifestations of climate change from international, South African and Limpopo Province perspective and experience. Household survey techniques is applied to investigate household food production experience and changing patterns, the environmental challenges faced, crops and livestock farming practices and the interventions made. Both qualitative and quantitative methods are used. Qualitative methods is applied to provide thorough descriptions of events about climate change, food production processes, types of crops and livestock, environmental challenges and forms of state interventions. These descriptions include analyses of contexts, including legislative frameworks, social and economic conditions, as well as households' intentions. Additionally, quantitative methods are used for investigation and recording of data on demographics, food production volumes and their historical trends.

1.6.2. Description of Study Area

Makhado Local Municipality is one of the four municipalities in Vhembe District Municipality of Limpopo Province. The municipality is located in the most northern region of Limpopo Province where the natural environmental conditions have always been marginal for food production. The average annual rainfall is 1 300mm, and it decreases east lows in the west north of the Soutpansberg mountain range (Makhado Local Municipality, 2010). The municipality's temperatures are very moderate in both summer as well as winter. The average temperatures for summer are around 30^{o}C whilst in winter it ranges between 20^{o}C and 25^{o}C. Higher temperatures are experienced

in the west and north of the mountain range where rainfall is low, creating ideal conditions for drought (Makhado Local Municipality, 2010). The fauna and flora ranges from Savannah plains to Mopani and Thorn Bushveld towards the south and west of Makhado and north of the mountain range. Lush sub-tropical vegetation and even rain forests and lakes are found towards the east of the municipality.

The municipality consists of five formal towns, namely, Louis Trichards, Vleifontein, Vuwani, Waterval and Dzanani; and, a total of 279 rural tribal villages (Makhado Local Municipality, 2010). The study exclude the five formal towns and focus only on the 279 rural tribal villages. It is estimated that the municipality has about 134 889 households distributed among the 279 rural tribal villages and five towns (Makhado Local Municipality, 2010). The structure of the traditional authority among the 279 rural villages is not the same; some of the villages are clustered and are headed by Indunas under the authority of a king, whereas some are under the authority of different chiefs. Most of the rural households live in poverty, lack adequate sanitation and facilities and rely on unsafe drinking water. The total number of the population of the municipality is estimated at 516 031 and it is growing at about 1.4% per annum with women constituting the majority because most men are engaged in the migrant labour system (Makhado Local Municipality, 2010).

Crop and livestock farming is still the main source of food production among the majority of households in the municipality, but their viability has evidently diminished

over the years. Historically, households used to be self-reliant and self-sufficient in their production of food related to crops such as maize, sorghum, ground nuts, and tropical fruits, as well as livestock, including cattle, sheep, goats, pigs and chicken. Presently, most households can barely produce adequate quantities of food from crops and livestock; and, increasingly they have sought to depend on purchased food commodities. For this reason, the study determines the linkages between climate change and food production in this municipality.

1.6.3. Kinds of Data Required

The study required textual data on the debates about climate change, as well as the implications to development activities including food production. Additionally, the data required included empirical evidence of climate change indicators and food production trends, including that about Makhado Local Municipality. That is, the study required data on the determinants of climate change, climate change manifestation, the poor households food production processes, types of crops produced, environmental patterns and challenges as well as the overall effects of climate change on food production. The data on climate change include the types of trends in global warming, emissions of greenhouse gases and fuels burned by poor rural households. Also, manifestations of climate change are represented by surrogates such as floods, drought, unseasonable precipitation patterns, soil erosion and temperature extremes.

Additionally, the study required data on changes, types and volumes of crops and livestock produced by households in the post-Second World War era. These data include the kinds of cultivation methods, techniques, strategies and implements that were and are used by households. Data on challenges associated with using these methods, techniques, strategies and implements was also required. Furthermore, opinions on environmental challenges that households face in food production was also required. Finally, data on changes of the quality of crop and grazing lands, the availability of water and the soil fertility was required.

1.6.4. Target Population

The target population for the study consisted of three categories in the Makhado Local Municipality: which are, households in the study area, key informants and government officials who are involved with issues of environmental management, climate change or food production. Households provided information on different food production methods, types and volumes of crops they produce and livestock they farm with, as well as their opinions on the effects of climate change on their food production systems.

The other categories of the targeted population that include key informants and government officials in the municipality provided information on the community-wide food production processes, challenges and historical trends of environmental conditions and climatic patterns, as well as interventions made in the study area over time. The key informants consisted of elders from different villages in the municipality, LED

managers and agricultural extension officers and Cattle Dip Tank operators from Hlanganani Agricultural Cost Centre.

1.6.5. Sampling Design

It was practically impossible to study the entire target population of 279 villages and the corresponding households, as well as all government official and elders from the rural Makhado Local Municipality. The study therefore conducted sampling to select a manageable sample for a survey. Given that there are three categories of the target population, different sampling designs (specifically, simple random and purposive sampling) were adopted at various scales for each category. For the selection of households, simple random sampling design was used to select 30 villages (Appendix E) from 279 which are found in the municipality. The 30 villages were selected using a random number table from a sampling frame that consisted of all the 279 villages arranged in alphabetic order of their names. The sampling frame was constructed using three digit figure starting with 000 for the first village listed. Purposive sampling was used to select 183 households from 9 of the 30 villages for questionnaire survey (Appendix E).

Additionally, another set of 9 villages was used to establish one focus group and interviews; and, the remaining 12 villages were used for observations of different production trends and settlements patterns were also conducted. That is, questionnaire survey was conducted in 9 villages, interviews and focus group conducted with different key informant from another 9 villages and observations conducted in the remaining 12

villages. Also, key informants from government structures were sampled using purposive sampling. The sampled official includes the LED manager, the dip-tank operators and the extension officers from Hlanganani Agricultural Cost Centre.

1.6.6. Data Collection Procedures

The study collected data through five different data collection techniques, namely literature review, household questionnaire survey, interview schedule, observation and focus group. By using literature review technique, desktop study was done to collect textual data on debates, determinants and manifestations of climate change from international, South African and Limpopo Province perspective and experience. Textual data was collected on different environmental aspects associated with crop and livestock production, including establishing the connection between these environmental challenges and patterns to the effects of climate change on food production.

The questionnaire survey technique was used to collect data among 183 households drowned from 9 villages with an average of 20 households per village. The questionnaire survey gathered information on household's experience and accounts of the changing patterns, the environmental challenges faced and interventions made. Also, it solicited information about the types, volumes and changes in crops and livestock farming practices, methods, techniques and interventions in food production over time. The interview schedule technique was used to solicit information about the community-wide food production processes and environmental concerns from the key

informants and government officials who gave an accurate account of historical trends of the manifestations of climate change, crop and livestock farming, and environmental challenges. Observation was done in 12 villages by looking at different production trends, settlement patterns and water resources structures amongst others. Focus group discussion was conducted with agricultural extension officers and Cattle Dip Tank operators from Hlanganani Agricultural Cost Centre.

1.6.7. Data Analysis Techniques

For the purpose of analysing data, the study adopted both qualitative and quantitative techniques. The three techniques of analysing qualitative data were adopted as description, classification and prediction or making connections of events. Description techniques were used to describe theoretical principles about the systems and processes of climate change and food production, as well as their relationships over time. This included the analyses of the determinants and manifestations of climate change, the environmental challenges of food production, the crops and livestock farming processes including the methods, techniques, challenges and the interventions. The classification technique was used to categorize ideas, types and events in order to establish patterns and trends of occurrences of climate change and food production, on the bases of which similarities and dissimilarities were detected and interpreted. Central to this classification was determinants and manifestations of climate change, types and volumes of crops and livestock produced. Different categories were examined to determine internal homogeneity and external heterogeneity, which provided the possibility of developing norms and making predictions about the relationship between

climate change and food production. Quantitative analysis was limited to the examination of demographic characteristics of households and food production statistics in the study area. IBM Statistical Package of Social Science 22 (SPSS) was used to generate statistical representation of the study's variables in terms of percentages and graphs were then created using Microsoft excess.

1.6.8. Validity and Reliability

The study used dependable concepts on climate change and food production, as well as research designs and methods that were used successfully in published research (see for example, Fraser, 2006). Studies that show the validity and reliability of the concepts of climate change include that of Olesen & Bindi (2002) and Tingem et al. (2009) were they evaluated the drastic effects of climate change on the means of production respectively. These studies have accurately captured the reality of global warming, temperature increases, unseasonable precipitation patterns, drought, floods, and so on, demonstrating the appropriateness of the concepts of climate change and food production to the changes being witnessed. The indicators used have also been demonstrated to be effective in capturing the relationship between climate change and food production (see for example Olesen & Bindi (2002); Fraser, 2006; Tingem et al. (2009). These studies have commonly achieved dependable results

The research designs, methods and techniques adopted for the study are appropriate, credible and dependable for analyses of the effects of climate change and food

production as attested to by the studies such as Reddy & Assenza (2009), Whitmarsh (2011), Tingem et al. (2009) and Simelton et al. (2009). These studies demonstrate the value of combining qualitative and quantitative approaches in an investigation such in the study. Tingem et al. (2009) adopted a design that is biased towards qualitative methods to investigate crop production response and adaptation to climate change. Overall, there is momentous evidence to show that a combination of qualitative and quantitative aspects of different designs and methods is most appropriate, dependable, feasible and practicable for the investigation of the effects of climate change on food production.

1.7. Significance of the Study

The study has both theoretical and practical significance. Theoretically, it adds incrementally to the knowledge and debates about climate change and its relationships to food production in rural areas within developing countries. It provides a unique rural Makhado Local Municipality perspective on the determinants and manifestations of climate change and their implications to household food production. Also, it contribute to the study area evidence for testing the principles commonly held about the effects of climate change on food production, thereby aiding the process of theorization of this relationship.

The practical contributions of the study will are in the form of revealing the systems and processes of climate change manifestations, the specific historical trends of these

manifestations over and their relationships to food production in the study area. The study raises consciousness within the communities in the study area about the crops and livestock that may not be viable given the on-going climate change trends that affect households' food production systems. It alerts households to unproductive food production systems in their settlements; and, it has a potential to make reasonable recommendations for interventions that could improve households' food production systems.

1.8. Ethical Considerations

The study required a set of ethical consideration in order to be accurate and credible. All the literature sources that the study reviewed and cited are acknowledged in order to avoid plagiarism. The study required the participation of household's members to provide information that could be sensitive and thus confidentiality and anonymity of the sensitive information was observed. Only names of key informant who agreed to be directly cited are mentioned in the data analysis chapter. Participation of household members and key informants was voluntary. The study will provide feedback of the results after the analysis in order for the subjects of the study (poor rural households) to benefit with the information and knowledge generated. The study made sure that no physical or emotional harm was caused to the respondents.

1.9. Conclusion

This chapter has provided the necessary topic information to contextualize the rationale of this study of the effects of climate change on rural food production. It has demonstrated that the effects of climate change are severe in such a way that they destabilise the food security options of the majority of households, particularly those who are found in rural areas of the developing countries. Furthermore, the chapter shows that households' dependence on rain-fed agriculture exposes their food security efforts to different stressors of climate change such as floods, drought and heatwaves. The study aim is to evaluate the effects of climate change on household food production processes in rural areas. The study adopted both qualitative and quantitative research methods which were aligned to normative and historical research designed in order that different aspects of climate change and food production variables are investigated. Different sampling, data collection and analysis procedures were also adopted in order to uncovered major prospects of the food production process, temperature and precipitation scenarios in the study area. However, the first major aspects of understanding the dynamics of climate change are analysed through reviewing different sources wherefrom theoretical principles of the connection between two variables under study are drawn. The next chapter draws such theoretical constructs.

CHAPTER 2

EFFECTS OF CLIMATE CHANGE ON FOOD PRODUCTION: A CONCEPTUAL FRAMEWORK

2.1. Introduction

Societal aspirations and search for progress has over the years brought into sharp focus the embeddedness of development with the environment, which is signified in the universal acceptance of the concept of sustainable development (Ortiz & Cunning, 2011; Glemarec & De Oliveira, 2012). The latter has, however, remained slippery and open to abuse that largely disguise unfettered "growthmania" and greed for accumulation of wealth for a few (Barnett & Adger, 2007; Jones & Thornton, 2009; Ortiz & Cunning, 2011). Indeed, the pragmatic strategies for the pursued of development have consequently been dominated by tenets of four fragmentary development paradigms, described by Glemarec & De Oliveira (2012) as "growth focused", "pro-poor growth", "green-growth" and "resilient growth". The dominant public discourse has instead perpetuated the fragmented binary ideologies characterised by the extremes of developmentalism and environmentalism. The hegemonic neoliberal discourse has continued to be captivated by the "growth-focused" development paradigm, which has allowed for practice that ignores the intricacies of the interface of development and environment in sustainable development (Adams, 2008). To this extent, the linkage between climate change, an inextricable component of environmentalism ideology, and food security system, an inseparable part of societal development, has been scarcely tested, especially for the rural population in developing countries, whose contributions to

global warming has been negligible. The effects of climate change, that could include but not restricted to land degradation, loss of biodiversity, change in hydrology and change in climate patterns resulting from enhanced anthropogenic emissions of greenhouse gasses, are believed to have a serious consequence on food production and food security (Ericksen *et al.*, 2009). People that are extremely affected by these changes are the vulnerable groups living in rural areas.

This chapter deals with six most important issues pertinent to this study in order to provide for a thorough description of the theoretical principles on the effects of climate change on rural household food production. The first part deals with the on-going discourse of climate change and its impacts in the third world countries. The systems and processes of climate change which include its determinants and indicators are also discussed. Furthermore, the poor rural household's food production systems are investigated. This chapter also analyses environmental conditions and challenges faced in rural area in order to determine the suitability of this areas to the success of food production processes amid climate change-associated problems. Furthermore the chapter provides a thorough theoretical assessment of the effects of climate change on rural household food production. Lastly, different household's climate change adaptation measures are examined.

2.2. The Climate Change Debate

There has been a considerable debate throughout the world around the discourse of climate change. This debate is understandable because the environmental problems that have been created by fear of resource scarcity as a major environmental concern in the 1960's and 1970's resulted in a rush of an unprecedented use of natural resources to grow the economies (growthmania) of many of the first world countries at that time (Swart, Robinson & Cohen, 2003; Redclift, 2005; Banuri & Opschoor, 2007; Prudham, 2009; Glemarec & De Oliveira, 2012). This process which coincided with the fast growing industrial revolution created environmental scars that are resisting to be healed and will still hurt the majority of third world countries for many decades to come. Heller & Shukla (2003) argued that the development efforts by first world countries which were obsessed with excessive use of environmental resources, industrialisation and market forces for economic growth purpose had put the earth at the brink of climate calamity. The impact of climate change are intensifying daily and leaving the majority of people without proper shelter and food security. The ecosystems have been victims of massive market and governance failures and the true worth of their services and costs of their degradation were persistently ignored by economic and development strategies of the first world countries (Heller & Shukla 2003; Prudham, 2009). The negative impact of these failures has been and is still felt hardest by the most vulnerable groups particularly the poor who are found in the third world countries (Adams, 2001; Redclift, 2005). Ironically, even when the damage was clear and inevitable the developmentalism ideologies and political influence from the west thought to solve poverty and inequality

problems of the third world countries through modernisation which emphasised industrialisation, urbanisation and free market economy amongst others.

The ideology of developmentalism was premised on the idea that for developing countries to be developed, they should imitate or emulate the progressive stances taken by the 'West,' emphasising that the adoption of modernisation theory and recreation of industrial world was required in an attempt to grow the economies of the third world countries (Adams, 2001). In such an instance, it was perceived that development can be possible only if developing countries accept and allow for "the imposition of the established world order" of the developed countries (Adams, 2001; Redclift, 2005; Mkandawire, 2011). So in one way or another, these western hegemony presented development "as a process that recreates the industrial world" and again as a progress down the linear path which need to only be measured through economic growth or "some economic abstraction such as per capita gross domestic product"(Adams, 1990: 5). Thus, the need to feed to the economic growth obsession saw a substantial and growing increase of human alteration of the earth. As a result, between one-third and one-half of the land surface is now transformed by human action and the carbon dioxide concentration in the atmosphere which is believed to be causing climate change has increased by nearly 30% since the beginning of the Industrial Revolution.

2.2.1. The Adoption of the Discourse of Sustainable Development

Interestingly in the post-1990 has seen a momentous intensification of the debate about development and the environment in the third world countries. This was due to the reenergised efforts stemming from the 1992 Rio Earth Summit where issues of development and sustainability were discussed intensively and extensively, including climate change. The need to continuously protect the environment whilst facilitating equitable economic development particularly in rural areas of these countries have remained a big challenge which has been apprehended by conflicts and contradictions amongst development planners and environmental experts (Adams, 2001; Swart et al., 2003; Redclift, 2005; Banuri & Opschoor, 2007). The progress towards achieving sustained and impartial development has proven to be the greatest challenge facing the human race (Swart et al., 2003). The adoption of the phrase sustainable development did not help much to solve the environment and development problems either. Sustainable development was adopted and codified at the Stockholm conference in 1972. The underlying complexities and contradictions surrounding sustainable development created contestations, controversies and mistrust among first and third world countries (Adams, 2001). Developed countries on one hand, expressed dire need to conserve and preserve natural resources for the consumption by the future generations; whereas, on the other hand, developing countries emphasised the need to maximise socio-economic emancipation through exploitation of the environment as a resource-base for development in order to address the multiple prospects of poverty affecting the majority of their citizens.

The environmentalist ideology of sustainable development identifies preservation and conservation of environmental resources as a preferred model of development (Adams, 1990). That is, sustainable development called for limited usage of natural resources in order that the future generation can also have the chance to access them. To facilitate this process, particularly in the third world countries, sustainable development was seen as the solution not only for environmental protection goals but also the integration of development activities into environmental planning processes. However, sustainable development to a large extent was seen as the infusion of environmental concerns into development discourse by Western environmentalists (Desai & Potter, 2002). This viewpoint resulted in resistance to the discourse of sustainable development by majority of third world countries. Despite the limited understanding of the phrase sustainable development and what it is aimed for, its facilitation gained currency beyond "the confines of global environmental organisations to the new jargon phrase in the development business" (Adams, 1990: 2). The implication of Adam's (1990) view is that the attempts by environmentalists to use the phrase sustainable development and other related terms such as eco-development & green development to capture the vision and rhetoric of development debate appeared to be founded on a lack of understanding of their context or complexity. The conception of this phrase has been controversial and has remained contested, without any identifiable coherent theoretical core (Adams, 2001; Beg, Morlot, Davidson, Afrane-Okesse, Tyani, Denton, Sokona, Thomas, La Rovere, Parikh, Parikh & Rahman, 2002; Banuri & Opschoor, 2007). This controversy has led to a missed opportunity to have clear coherent strategies towards the solutions to the problems of poverty and environmental exploitation.

The evolution of sustainable development thinking has always been linked to the Western ideas about nature and its conservation and how these ideas were expressed on the developing countries in the 20th century, first as colonies and then as independent developing countries (Adams, 1990; Adams, 2001; Mkandawire, 2011). As defined by the Brundtland Commission of 1987, sustainable development is seen as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. The simplicity of this definition allowed for the abuse of its implementation and prompted a continued debate about the question of what is to be sustained and what is perceived to be the most sustainable course of action (Redclift, 2005; Robinson, Bradley, Busby, Connor, Murray, Sampson & Soper, 2006; Sneddona, Howarthb & Norgaardc, 2006). Redclift (2005) argue that, it is both the present and future levels of production and/or consumption that need to be sustained. The argument is that the growth of global population will lead to increased demands on the environment, thus the ideas of sustainable development should incorporate that. Adams (2001) alluded to the fact that the abuse of the phrase 'sustainable development' was and still is intricately linked to the 'simplistic' yet 'slippery' definition that is generally accepted.

The concept of sustainability seemed to exist mainly within quotation marks; it does not have a clear meaning. Its powers are found to be based much on the discourses surrounding it, rather than in any shared substantive value it should have (McGuigan, Reynolds & Wiedmer, 2002; McKibbin & Wilcoxen, 2002). The fact that different people

identify different objects of sustainability is, among other things, the reasons why there are many contradictory approaches to sustainable development. Thus, the differences in approaches constantly reflect differences in underlying social commitments from different actors of sustainable development. In other instance, this has led to issues to be forcibly associated with the phrase 'sustainable development' in order to justify and/or embellish particular actions which are found to be unsustainable in the long run (Adams, 2001). For instance, in developing countries it is more likely to find resistance on the idea of preserving resources for the future because of the need to service the current social-ills affecting the majority of communities; more so that the environment is considered to be a resources base of development.

The poor in rural areas understandably value the present above the future. In other words, for the poor, present challenges of survival are more pressing than the sustainability of resources for future consumption (Desai & Potter, 2002; Heller & Shukla, 2003). The short and long term results of this misunderstanding has meant that environmental costs continue to be passed from one generation to another, within and between societies, with the poor likely to be worsened of their deprivation. Because of power and control, the "industrialized western countries are continuing to dump their toxic wastes in non-industrialised countries", while simultaneously drawing most of their energy, food and mineral needs from there (Redclift, 2005). Many natural resources are continuing to be dedicated exclusively to the service of the western 'elevated lifestyles of the rich and middle-class people' in ways that perpetuates intergenerational and intra-generational inequalities among developed and developing countries (Adams,

2001; Banuri & Opschoor, 2007). Sustainable development discourses suggests that the perceived need for global management of the environment stemmed, in part, from the assumption that it provided a way of correcting the anomalies of economic and trade policy, with climate change challenges at the forefront.

2.2.2. Emergence of Climate Change in the Development Debate

The emergence of climate change in recent years can be identified as an extension to the continuous efforts to achieve sustainable development, whose governance created ideological contestations about the relevance and irrelevance for developing and developed nations. Climate change is believed to be caused by human induced activities that are leading to concentration of toxic gasses into the atmosphere. The anthropocentric nature of this understanding of climate change is in one way or the other in line with the debate about sustainable development which emphasis the need to limit human interaction with nature and reduction of development activities that create carbon emissions (Robinson & Cohen, 2003). There is a direct link between climate change policies and the sustainable development agenda in that they both deal with issues of energy efficiency, renewable energy, transport and sustainable land-use policies among others (Cohen, Demeritt, Robinson & Rothmon, 1998). The oxymoron on climate change understanding has borne exclusively deleterious impacts on the economic development of developing countries wherein the prejudicial and quixotic discourse of sustainable development amplified suspicions and mistrust between first and third world countries (Glemarec & De Oliveira, 2012). However, the continuous

debate on whether climate change is influenced by concentrations of greenhouse gases in the atmosphere through, for example industrialization or it is just a natural process of natural change overtime has not deterred its threat to the development of socio-economic and agricultural activities of many countries across the globe.

The world has in recent years experienced unprecedented nature-based climatic disasters, leaving the majority of the poor devastated. Unfortunately, global efforts through, among others, the Kyoto Protocol and the Clean Development Mechanism (CDM) have yielded negligible progress towards establishing measures to solve climate change problems and impacts. Instead, developed countries have continued emitting according to unchanged patterns of their unfettered consumerism and production while imposing limitations on developing countries' access to environmental resources. Heller & Shukla (2003) argue that the quest to mitigate the impact of climate change has always been derailed by power relations and misunderstanding between first and third world countries. In pursuit for continuous sustainable economic growth, developed countries have constantly rejected proposals to reduce gas emissions from their economic dependent industries. Whereas developing countries have also raised concerns for the need to accelerate economic development of their societies faced with high rate of poverty, unemployment and many other social ills. Robinson & Cohen (2003) wrote that the fundamental contradictions between the renewed call for economic growth in developing countries and the need to enhance levels of ecological conservation and power relations among the local and global actors and institutions

supporting climate change mitigation has been in the forefront of challenges facing the world today.

For many years, international policy prescript including those governing climate stabilization have developed largely within the institutional, economic, and political context of industrialized countries, rather than within developing countries (Heller & Shukla, 2003; Robinson & Cohen, 2003; Mkandawire, 2011). This is a cause of concern as developing countries are also required to implement these policies; notwithstanding the fact that there was no thorough contextualization of the socio-economic circumstances of these countries. Furthermore, the most disturbing aspects of climate change impacts are projected to fall disproportionally to these areas, thus, increasing existing development inequality not only amongst household of third world countries but also political economies of the developed and developing counties (Heller & Shukla, 2003; Robinson et al., 2006). Third world country's economies are still less progressive and require serious interventions and strategies to grow in order to promote socio-economic development compared to first world countries. In this sense, the efforts to adopt measures to promote sustainable development and reduce human activities contributing to climate change are remaining a challenge.

For developing countries the measures to promote reduction in greenhouse gas emissions will result in a shift of production and job creation opportunities with social, economic and demographic consequences (Redclift, 2005). Thus, halting development

efforts aimed at creating industrial employment and growing livelihood activities of the previously discriminated rural populations. Ironically, there is a paradox link between climate change, and socio-economic problems. To this oxymoron, efforts to control human induced climate change may prove to limit socio-economic transformation of the society on one hand and on the other hand, the direct indicators of climate change in the form of floods and drought are already having adverse effects on the lives and livelihoods of the rural communities (McKibbin & Wilcoxen, 2002; Redclift, 2005). Additionally, health-influence of vector-borne diseases, through heat waves, increased weather variability, and deterioration of local air quality and water shortage are found to be the most devastating effects of climate change in rural areas.

2.2.3. Complexity in Balancing the Course for Climate Change and Development Mandate

The interesting aspects of the debate on climate change and economic development is the fact that the political rhetoric has always replaced the environmental concern of climate change (McKibbin & Wilcoxen, 2002; Redclift, 2005; Robinson et al., 2006; Sneddona et al., 2006; Prudham, 2009). Development and sustainability processes have been capitulated to the western hegemony towards the management and control of resources in the third world. Economic and political inequalities in access to opportunities have dramatically increased within and between most societies, making pragmatic governance toward social and environmental goals increasingly difficult (Redclift, 2005: Robinson et al., 2006). Thus, climate change is found to have been a major driving force behind accelerated vulnerability of the poor in the third world. While

climate change is perhaps the best known aspect of current global challenge, it has also contributed to loss of biodiversity and changes in atmospheric composition. Redclift (2005) argue that, climate change is a reality and will affect the poor in developing countries in many ways. “Africa will suffer most from climate change, not only because its climate will be the worst affected, but because its underdevelopment will leave no room for coping” (Mkandawire, 2011:10). Thus, the avoidance of virtually every predicted disaster associated with climate change will require high levels of technological and social capability on behalf of the African continent (Mkandawire, 2011). However, the most concerning aspects of the management of climate change is the power relations between developed and developing countries. Most of developed countries continue to create stumbling blocks on achieving common agreements to curb and control the release of gas emissions, stating the interference of such actions to the progressive route towards sustainable economic growth (Robinson et al., 2006). For example, United State of America which is estimated to emit 35% of greenhouse gas annually has persistently refused to ratify the Kyoto Protocol. However, developing countries are repetitively pressurised to adopt measures suitable for greening of their development process to avoid the consequences of climate change.

The social dimension of development sustainability raises a number of important “fairness” issues in the context of climate change. On a per capita basis, greenhouse gas emissions from developing countries remain far below those of the developed countries well into the future (Adams, 2001; Beg et al., 2002; Banuri & Opschoor, 2007). The increase of disparities in wealth between developed and developing world and

redistributive impacts are some of major reasons for concern about the climate change phenomena. Also, globalization has contributed to an increase in economic inequality and environmental deterioration by concentrating power in the hands of those who benefit from unsustainable forms of growth and resource use. For instance, ongoing negotiations conducted under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) have so far produced the Kyoto Protocol. Unfortunately some development and environment commentators perceive the Kyoto Protocol a deeply flawed agreement that is proving to be both economically inefficient and politically impractical (Beg et al., 2002; Banuri & Opschoor, 2007). Since Kyoto agreement, there has been a less to be desired on the quest towards control of gas emissions. The challenges of greening the economy and having good environmental governance in place have several facets and require a series of changes that may not be easy to carry out in a current economic and political context. Furthermore, the failure to stem the tide of unsustainable human activities has always been linked to both ineffective institutions and a general lack of political will on the part of governments and citizens at multiples scales.

The future agreements beyond Kyoto Protocol on mitigation and adaptation should recognise the diverse situations of developing countries with respect to their levels of economic development, their vulnerability to climate and their ability to adapt and mitigate (Robinson et al., 2006; Sneddona et al., 2006). Currently, the rate of economic growth is viewed as the pre-eminent policy goal for many developing countries; thus, offering genuine hope of narrowing the gap between the rich and poor countries

(McGuigan et al., 2002). As such, a serious threat to this momentum could also constitute a threat on global stability and mutual trust. In fact, the economic growth of developing countries should increasingly be viewed as a global responsibility because it is the only mechanism that the world can use to address the vast inequality of income, wealth, and access to basic needs, human rights, and political participation (Swart et al,. 2003). So, McKibbin & Wilcoxen (2002) argue that any agreement that would call for a switch to less carbon intensive fuel sources should adequately recognise economic losses that might be occasioned by such a switch. There could be significant trade-offs associated with deeper levels of mitigation in some countries. For example, where developing countries are dependent on indigenous coal and may be required to switch to cleaner yet more expensive fuels to limit emissions. For climate change to be dealt with in a sustainable manner, support for developing countries should be in a form of direct aid, technology transfer and debt relief. This will help in the progress towards sustainable forms and levels of production and consumption. In the future, it would be necessary not only to induce adjustment in industrialised countries, but also to re-orientate the growth process in the developing world towards de-carbonisation.

2.2.4. Recommended Stances to Curb Climate Change Problems

Successfully limiting global climate change to “safe” levels in the long-term requires connecting climate change policies to economic and sustainable development strategies in both developing and industrialised countries (Robinson et al., 2006). This approach towards harmonisation of the three processes, limiting climate change,

promoting economic and sustainable development should go beyond Kyoto Protocol agreements and understandings. In terms of treating climate stabilisation and economic development as separate and equal, there should be an adoption of strategy to re-integrate the two global policy goals input by separating responsibility and funding from action (Cohen et al., 1998; Desai & Potter, 2002). The aim should be to achieve stabilisation of greenhouse gas concentration with a time-frame sufficient to allow ecosystems to adapt naturally to climate change and to enable economic development to proceed in a sustainable manner. From an economic perspective, there should be structural change in production patterns to do with a variety of causes including changing consumption patterns, responses to fuel price rises, energy and emissions efficiency gains facilitated through policy interventions (Heller & Shukla, 2003). There is a need to go beyond thinking of unidirectional effects of climate change on economic and sustainable development. The relationship should be viewed as part of a complex system of interactions, ranging from concrete issues of technology choice and innovation, to question of institutional design and management, through to more abstract questions related to identity, agency, control and power (Robinson et al., 2006).

Measures to promote sustainable development policies and to protect the climate systems against human-induced change should be appropriate for the specific conditions and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change (McKibbin & Wilcoxen, 2002; Redclift, 2005; Sneddona et al., 2006). A successful solution to the climate problem will have to come from within the

development process; hence it should begin, rather than end, with developing countries, and be based on a deep understanding of how development occurs in these countries (Sneddona et al., 2006). In other words, developing countries that adopt greenhouse gas friendly sector policies must ensure that these policies are not implemented at the costs of reduced economic development.

It is clear that issues of global environmental justice are as important as they were when the concept of 'sustainable development' was in its infancy (Swart et al., 2003). There should be rethinking of the power and economic relations between third world developing and first world developed countries. The current material realities of science and the environment in the 21st century demand a re-engagement with the social, political, cultural and economic consequences, something which has largely been ignored by the (market) liberal consensus (Heller & Shukla, 2003). The neo-liberal capitalist intentions of the western countries should be guarded against if third world countries are to progress towards socio-economic transformation of their societies. Whereas, the quest towards limiting the impacts of climate change in the third world is necessary, policy adoption will require a distinct way of making decisions at the different levels to bring together economic, social and environmental objectives in a long-term common interest. If there are such close linkages between climate change and other environmental and socio-economic development needs, both in the area of causes and effects, it seems obvious that policies should take these into account (McKibbin & Wilcoxen, 2002; Prudham, 2009). It is clear that climate policies will mostly impact development objectives in a negative way and that the first priority of developing

countries policy makers is to reduce poverty and encourage economic growth. However, such will depend on the strategies, instrument, and context of the development policies adopted.

The question is, which policy intervention and on what level of governance can lead to a sustained economic growth while there is reduction of the carbon footprint? Can green capitalism or implementation of green economy/business reverse the impact of rapid industrialisation and market forces? Green capitalism is perceived as a set of responses to environmental challenges and environmentalism that relies on harnessing capital investment, individual choice, and entrepreneurial innovation to the green course (Heller & Shukla, 2003). According to Prudham (2009), green capitalism is only a possibility rather than a reality. Indeed, for some business interests and representatives of corporate business, sustainable development was a necessary further stage in the development of capitalism, to be embraced rather than denied. The reforms for improving governance and greening the economy are often opposed by important stakeholders both rich and poor who are negatively affected in the short term. There are glaring problems associated with green capitalism that are mash-up of environmentalism with capitalism (Heller & Shukla, 2003). One of these is the tethering of environmentalism to a political economy whose stance is growth for growth's sake rather than making a contribution towards protecting the environment and growing livelihoods for the poor.

Climate change mitigation strategies should offer an opportunity to revisit development from a new perspective, for example on issues such as energy, forestry, agriculture, transportation and population (McGuigan et al., 2002; McKibbin & Wilcoxen, 2002; Heller & Shukla, 2003). Furthermore, the climate strategies should explicitly address the fundamental needs of developing countries if they are to be constructively and seriously engaged in common responsibilities for climate protection. For instance, the recently adopted green growth strategy in Southern Africa is aimed at helping policy makers keep ahead in the race between complexity and ingenuity, scarcity and de-materialisation, industrialisation and de-carbonisation, entrepreneurial incentives and inequity (Prudham, 2009). Through this complex process climate change actions should consider a full cycle from socio-economic and technological driving forces, through emissions and concentration of greenhouse gases, physical change in the climate system, impacts on biological and human systems (Prudham, 2009). Technological advancement is essential in this regard. New and cleaner technologies can be utilised effectively by businesses, within a policy framework that is conducive to more sustainable practices at the same time stimulating economic growth without increasing pollution. Technology options to reduce greenhouse gas emission include efficiency improvement, renewable energy and nuclear power (McKibbin & Wilcoxen, 2002; Heller & Shukla, 2003; Prudham, 2009). The monetary value for this interventions requires a huge investment from governments and international bodies responsible for climate change mitigation particularly in the third world countries.

The debate above creates a thorough analysis within which the understanding, contestation and complexities surrounding the climate change debate emerge. It is within this assessment that the systems and processes of climate change underlie to reflect the determinant and also the indicators of climate change particularly in third world countries such as South Africa.

2.3. Systems and Processes of Climate Change

In the short space of time, the so-called enhanced greenhouse effect, caused by changes in the earth radiation balance due to the accumulation in the atmosphere of carbon dioxide and other radioactively sensitive gases, has gone from being a little-known technical concern of a few atmospheric scientists to a subject of widespread public anxiety and international regulatory interest (Fraser, 2006; Barnett & Adger, 2007; Hahn, Riederer & Foster, 2009, Jones & Thornton, 2009). Currently, climate change is regarded as one of the 21st century's common and primary global concern (Tingem, Rivington & Bellocchi, 2009). The climate change duress has categorically been linked to the recent increase in frequencies of heat waves, drought and flooding events, rising sea levels and acid rain amongst others. The causes and determinants of climate change are still under a scope of debate however the most noted link has been the increase in concentration of carbon dioxide in the atmosphere (Jones & Thornton, 2009). Interestingly, not only was climate change initially treated separately from broader economic development and sustainability issues, it received disproportional political and scientific attention. This was partly due to the perceived high costs of

addressing the problem in the industrialized countries within which the economies depend on the concerned fossil fuels. Unfortunately, the diverse manifestations of climate change for example through floods is found to be triggering problems among the majority of people particularly in rural areas which leave them stranded and sometimes without food and income to purchase basic needs for their households (Tingem et al., 2009). This section deals with determinants and indicators of climate change in order to get a clear understanding of its systems and processes.

2.3.1. Determinants of Climate Change

The determinants of climate change continue to be a moot point. Whereas some trace it back to anthropogenic factors, others explain it through natural phenomena. That is, the distinguished characteristic of the literature has been a progressive broadening of the debate from primary focus on the physical and natural science of climate change to a growing interest in the human dimension of the problem (Fraser, 2006; Hahn et al., 2009). Tingem et al. (2009) stated that on one hand climate change could be explained as naturally event which result on change in the sun energy or orbital cycle. In the late 1980s natural scientists identified climate change as a problem related to the long-term disturbance of the global geo-biochemical cycles and associated effects on global climatic patterns, modelled in complex global circulation models (Jones & Thornton, 2009; Reddy & Assenza, 2009). As such, climate change was divorced from its social context. However, on the other hand the debate goes further to align climate change to the increase of the concentration of the greenhouse gases, surface aerosol and black

carbon in the atmosphere. These greenhouse gases which comprise of water vapour, carbon dioxide, methane, nitrous oxide amongst others, are gases in an atmosphere that absorbs and emits radiation within the thermal infrared range (Fraser, 2006). Basically, these gases help trap heat in the earth's atmosphere and the more greenhouse gases there are, the more heat gets trapped. The heat is trapped through a process called the greenhouse effect and the result of the effect is global warming which causes climate change (Fraser, 2006; Reddy & Assenza, 2009). When there are higher amounts of greenhouse gas emissions, global warming is further accelerated.

Some of the gases which concentrate in the atmosphere are caused by burning of fossil fuels such as coal, oil and gas. Whitmarsh (2011) stated that climate change occurs when carbon dioxide gas trap solar heat in the atmosphere the same way as glass traps solar heat in the sunroom or a greenhouse. The more carbon dioxide is added to the atmosphere, it increasingly prevents solar energy from escaping into outer space and if the situation stays unchanged for a longer period, the average temperature of the atmosphere would certainly increase (Devereux, 2006; Whitmarsh, 2011). Although greenhouse gases can trap energy and make the atmosphere warmer with the concentration of those gases increasing, it is far from clear what those facts mean for global temperatures. A long list of scientific uncertainties makes it difficult to say precisely how much warming will result from a given increase in greenhouse gas concentration, or when such warming will occur or how it will affect different regions and ecosystems. But, according to Tingem et al. (2009), over the past three centuries, the concentration of carbon dioxide has been increasing in the atmosphere because of

human influence. Hence, Reddy & Assenza (2009) argued that even though the poor rural households than any other social group contribute less to the release of gas emissions to the concentration of carbon dioxide in the atmosphere, they are the most affected by the natural hazards such as floods and drought which are associated with manifestation of climate change.

Even though the debate about the determinants of climate change continues, the most identified and globally accepted course has always been aligned to human induced anthropogenic processes leading to concentration of greenhouse gasses to the atmosphere. The United Nations Convention on Climate Change identify climate change to be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods. This change which is believed to be influenced by human activities is significantly more rapid and dangerous than what was thought earlier (Intergovernmental Panel on Climate Change (IPCC), 2007). Some of the human activity contributors include economic activities i.e. energy production, industrial development, transport and land use which many of rely upon fossil fuels. Thus, progress towards addressing climate change problems will in one way or another have an impact on the economic status of any country concern (Devereux, 2006). For example, actions in reducing the release of greenhouse gasses from industries can slowdown growth of per capita income and economic growth of any country. Again, a momentous amount of investment will be needed in energy efficient production, fuel switch, land use change, carbon storage and sequestration and improving the efficiency

of conversion of fossil fuels into energy. Even though such actions are feasible and appropriate, less energy and carbon intensity patterns of consumption and production would have a huge impact on the economic growth and greenhouse gas emissions.

2.3.2. Indicators of Climate Change

The science of climate change remains unresolved, notwithstanding the innumerable events that are commonly identified as its manifestation by its proponents (Whitmarsh, 2011). Due to the complexity of the linkages between events such as floods, high temperatures and drought with climate change, the science has continued to be contested (Devereux, 2006; Jones & Thornton, 2009; Reddy & Assenza, 2009; Whitmarsh, 2011). To some extent, the winter snows in the northern hemisphere tend to create question whether the average temperature of the planet is increasing. Currently, it is estimated that the global mean temperature of the earth is rising by $0.7\ ^{0}$ c and will continue on an upwards trend imposing costs in the form of heat waves, frequency of extreme events, and recession of glacier; however, such are found to still be within the bouts of common experience (Devereux, 2006; Reddy & Assenza, 2009). Reddy & Assenza (2009) argue that, there is less certainty about the relationship between climate change and the occurrence of natural disasters. In spite of the uncertainty, there is consensus that global warming is and will continue to precipitate an increase in cyclonic wind and rain intensities, intensified droughts and extreme floods associated with El Niño, increased Asian monsoon rain variability, and intensity of mid-latitude storms (Tingem et al., 2009). These major changes will take place worldwide thus

creating a profound influence on the earth and its people in the next decades. The common understanding is that any change in the mean climate will affect the frequency of extreme events even though it is impossible to predict exactly what the frequency and distribution of these events will be. For example, Hahn et al. (2009) argue that in the coming decades, due to anticipated further increases in greenhouse gas concentrations in the atmosphere, changes in climatic variables are predicted to increase the earth's mean surface temperature and would likely be accompanied by increased precipitation which can lead to flooding. The most vulnerable communities are those found in the third world countries, with African continent being the most exposed because of its higher rates of poverty, limited infrastructure and insufficient access to resources to cope, particularly after climate change induced disasters.

Indeed, climate change result from different activities all over the globe (with rather unevenly spread contributions to it); however, its impact vary differently in different countries, depending on local/regional environmental conditions and on difference in vulnerability to climate change (Devereux, 2006). In some cases weather shocks may trigger a sequence of 'entitlement failures' in production, labour, trade and (informal) transfers which, if severe, may result in a food crisis or famine unless public action intervenes to mitigate these impacts (Devereux, 2006; Fraser, 2006). In others case climate induced events may go as far as causing under-investment to precipitate long-run agricultural stagnation and rural poverty particularly in countries that are dependent on rain-fed agriculture (Fraser, 2006). Furthermore, in recent years different production systems are been forced to shift in order to response to rainfall and pasture quality.

Thus people who were previously dependent of self-provisioning are failing to produce enough food and their access to food is now determined by the prices from markets leading them to be food unsecured. This and other related traumatic experiences have been hypothesized to precipitate short and long-term personal loss and grief as victims may face loss of life, serious injury, and devastation of their property and communities (Barnet & Adger,2007; Tingem et al., 2009). Furthermore, Barnet & Adger (2007) identified some of the effects from these natural disasters to vary from shock, anxiety disorders, sleep disturbances, impaired interpersonal relationships, depression, and suicide.

Even though the impact of climate change can be severe particularly in rural areas were agricultural activities are still the pillars for food security, different households have always found ways to minimise the effects of these events. Some efforts to mitigate the potentially devastating impacts of droughts and floods on agriculture are found to be pre-emptive rather than reactive, and involve enhancing farmers' access to inputs improved seeds, chemical fertilisers and other tools to boost production and/or minimise crop losses (Devereux, 2006; Khandlhela & May, 2006; Reddy & Assenza, 2009). Other strategies which are found to be not so appealing to respond to production failure, high food prices and limited employment opportunities include selling of household productive assets to buy food. Selling of these productive assets is found to not only erodes the household's productive capacity and undermines its future food production and income-generating potential but also to have a long term impact on the entire household economy.

Climate change is continuously manifesting itself through different indicators such as rising sea levels, El Nino, La Nina; hurricane, acid rain, flood, heatwaves and drought. Hence, this study identified two categories of occurrence to discuss which are virtually universally accepted to be the primary indicators of climate change, namely flood and drought. Barnet & Adger (2007) stated that flood and drought had continuously destabilized the poor household's food production, clean water, energy supply, and environmental health amongst others in the rural areas.

2.3.2.1. Manifestation of climate change through floods

The manifestation of climate change through floods is perceived to be the most dangerous event signalling the existence of climate change (Khandlhela & May, 2006). Unlike droughts and other natural or manmade hazards which evolve over time, floods occur catastrophically with little or no lead time. Climate change increases the surface temperature, changes precipitation patterns, which constitute into severe heavy rains. The sea levels rises when the water warms, glaciers and ice melt into the sea. Hahn, Riederer & Foster (2009) wrote that the long term changes in the hydrological cycle that is the flow of water throughout earth due to higher temperature; more evaporation; melting of ice; more intense rainfall contribute to the manifestation of climate change in the form of floods. Interestingly, when climatologists discuss floods, they typically are referring to hydrologic event, however, policy makers typically refer to floods as damaging hazard. Extreme floods which constitute heavy rains have been found to not

only frustrate household food production processes but also contribute to destruction of infrastructure, closure of schools, damage to traditional dwellings and sometimes loss of lives (Ginexi, Weihs & Simmens, 2000; Tarhule, 2005; Khandlhela & May, 2006; Hahn et al., 2009; Armah, Yawson, Yengoh, Odoi, & Afrifa, 2010). Consequently, majority of victims of floods face a long steep recovery curves to recoup losses or return their activities to pre-flood levels and in a worse case some never completely recover. As a result, the entire communities may continue to suffer the effects of flooding long after the public has forgotten about such a particular event. Thus, issues of access to resources and households vulnerability are tested during such events.

Flood risks can arise from a variety of sources including extreme rain events and very weak or a complete lack of mitigation programs such as storm drainage facilities, flood warning systems, and flood zone demarcation and enforcement programs (Ginexi et al., 2000). Vulnerability to these risks arises from the lack of rehabilitation mechanisms such as flood insurance. For example, flood victims have no recourse to compensation or reimbursement beyond emergency relief provided by donor agencies (Tarhule, 2005). These and other important risks are prevalent in rural areas. However, in recent years rapid urban population growth and its associated environmental impacts also are found to have serious implications for flood hazard exposure and vulnerability. Rapid population growth has overwhelmed urban planning and regulatory agencies, permitting the development of unplanned shantytowns, some of which establish in flood prone zones where land is cheap or free; thus exposing people to flood risks (Hahn et al., 2009; Armah et al., 2010). Hahn et al. (2009) wrote that floods therefore can trigger a

rapid deterioration of social infrastructure and extend existing vulnerabilities; thus, also limit government efforts to assist communities because in the aftermath of flooding, many of the flooded areas are inaccessible due to breakdown of these key infrastructure, including bridges and roads. Furthermore, the onset of floods could lead to incidence of disease which potentially could lower labour available for non-agriculture activities and also reduce non-agriculture income that community members earn (Armah et al., 2010). Thus decreasing household income earnings and precipitating food insecurity. In other areas within which communities are subsistence production bound, destruction of crops by floods had made it imperative and compulsory for the community members to shift and diversify their dependence on agriculture income to non-agriculture income and livelihoods in order to cope.

Consequently, some communities have thought to settle to wetland in order to maximise their agricultural production. Wetlands are found to provide essential income and nutrition benefits in the form of agriculture, grazing resources, non-timber forest products, fuel wood and fishing for local populations (Hahn et al., 2009). These wetlands also serve wider regional economic purposes, such as providing dry season grazing, agricultural surpluses and groundwater recharge of the formation aquifer and 'insurance' resources in times of drought. However, when floods comes in these areas, it end up destroying crop products, kills animals and displace poor farmers from their traditional sources of water and land, thus forcing them to move to more fragile environments prone to land and resource degradation (e.g. mountainous areas). The effects of floods has been extremely felt by the majority of households in rural areas

were own food production is still in the forefront (Tarhule, 2005; Khandlhela & May, 2006; Hahn et al., 2009). People in these areas have been struggling to get employment and establish livelihoods which are sustainable enough to provide food security outside agricultural spectrum. The extreme impact of floods on these natural-dependent communities is found to be complex (Tarhule, 2005). Being essentially agricultural producers, the main consequence of flooding has been the destruction of food crops on farms as well as seeds stores; and eventually culminating in a decline in the whole food production process (Armah et al., 2010). One of the most important aspects to this problem is the damage inflicted on seeds. Most subsistence and small-scale farmers' safe-guard the most viable portions of their produce as seed for the next planting season. So if floods significantly damage food crops just nearing harvest that will mean that the farmers' seed supply for the coming agricultural year would have been jeopardized (Khandlhela & May, 2006). Floods may therefore affect seed supply either through affecting crop production (on farms) or destroying seed stores (in homes). Either way, the lack of seeds for subsequent planting could generate a reinforcing effect of lower food production and another resulting lack of seeds.

2.3.2.2. Drought as an indicator of climate change

Of all the 21st century natural hazards, droughts have had the greatest detrimental impact observed in a large scale in almost all continents, affecting large areas in Europe, Africa, Asia, Australia, South America, Central America, and North America (Batterbury & Warren 2001; Heim, 2002). The consequence of climate change and

global warming is not the change only in averages but the overall increase of extreme events. Among the extreme meteorological events, droughts are possibly the most slowly developing ones that often have the longest duration and the least predictability among all atmospheric hazards (Mishra & Singh, 2010). Drought occurs when there are changes in the hydrological cycle which ultimately transform the precipitation process (Devereux, 2007; Simelton, Fraser, Termansen, Forster & Dougill, 2009). When this change occurs and develops, the normal expected precipitation fails to occur at the expected time (season). Thus, limited rainfall leads to a loss of soil moisture, surface runoff and groundwater recharge. However, Fraser (2006) emphasised that drought is more than a simple lack of rainfall in a hydrological sense, it occurs when surface water supplies steadily diminish during dry spell and in an agricultural sense it occurs when the moisture shortage lasts long enough and hits hard to negatively impact cultivated crops and livestock.

Drought can take shorter or a longer period; however the persistent moisture deficiency below long-term average condition; balanced precipitation and evapotranspiration will increase the period of drought in a specific area (Fraser, 2006; Devereux, 2007; Mishra & Singh, 2010). According to Devereux (2007), not all droughts are formed equally. Moisture deficits may have very different consequences depending on the time of year at which they occur, pre-existing soil moisture content, and other climatic factors such as temperature, wind, and relative humidity can also pre-empt the manifestation of drought particularly in rural areas. Moreover, in most of rural areas affected a combination of high dependence on rain-fed agriculture, while rainfall is increasingly

erratic, had left household livelihoods highly vulnerable to this weather shocks. Consequently, most continents around the globe have experienced frequent droughts in the last three decades. This condition is being aggravated due to growing water demands with limited source of water as well as changes in climatic patterns. Increasing the efficiency of water use within agricultural systems is an essential priority in many regions and availability of water is also essential to sustaining human health and environmental quality (Farooq, Wahid, Kobayashi, Fujita & Basra, 2009; Mishra & Singh, 2010; Mkhabela, Bullock, Gervais, Finlay & Sapirstein, 2010). However, due to the high growth of population and expansion of agricultural, energy and industrial sectors, the demand for water has increased leading to scarcity occurring almost every year in many parts of the world.

Limited water has affected natural habitats, ecosystems, and many economic and social sectors, from agriculture, transportation, urban water supply, and the modern complex industries. There is wide variety of sectors affected by drought, its diverse geographical and temporal distribution, and the demand placed on water supply by human-use systems (Farooq et al., 2009). For example, in Africa's ecologically vulnerable regions drought has had a devastating impact fostering a major impetus for the establishment of the United Nations Convention on Combating Desertification and Drought. However, the frequency of droughts in the region is thought to have continuously increased in recent years. Most of African countries are dependent on rain-fed agricultural of which in recent year have been generally characterised by low and uncertain rainfall and crops of limited production potential that are, however, generally more stable in such

environments (Fraser, 2006; Mkhabela et al., 2010). In these areas, hot temperatures, low relative humidity, and desiccating winds are often adding to the impact of the lack of rainfall.

The understanding and the reasons for the occurrence of droughts are found to be very complex. Often there is confusion between a heat wave and a drought. The distinction lies on the typical time scale associated with a heat wave which can be in terms of more or less a week, while drought may persist for months or even years (Quiring & Papakryiakou, 2003; Mishra & Singh, 2010). However, the combination of a heat wave and a drought has dire socio-economic consequences. Furthermore, the explanation of drought is dependent not only on the atmosphere but also on the hydrologic processes which feed moisture to the atmosphere (Quiring & Papakryiakou, 2003; Parry, Flexas & Medrano, 2005; Bond, Lake & Arthington, 2008). Bond et al. (2008) argued that, once dry hydrologic conditions are established the positive feedback mechanism of droughts sets in, where the moisture depletion from upper soil layers decreases evapotranspiration rates, which, in turn, lessen the atmospheric relative humidity. The lesser the relative humidity the less probable the rainfall becomes, as it will be harder to reach saturation conditions for a regular low pressure system over the region.

Consequently, only the disturbances which carry enough moisture from outside the dry region will be able to produce sufficient rainfall to end drought conditions. Unfortunately, the severity of drought is unpredictable as it depends on many factors such as

occurrence and distribution of rainfall, evaporative demands and moisture storing capacity of soils (Parry et al., 2005; Fraser, 2006; Mkhabela et al., 2010). Moreover, the onset and the end of a drought are difficult to determine as it develop very slowly and becomes difficult to quantify in terms of spatial extent and intensity; furthermore its impact often accumulate over a considerable period and may linger for years after termination (Heim, 2002). Distribution of rainy days during crop growing seasons, intensity and duration of rain, and onset and termination, play a significant role in the occurrence in this process (Fraser, 2006). Ironically, most droughts occur during the crop growing season when the majority of annual precipitation is supposed to be received; thus leaving devastating effects to households' food security efforts particularly in rural areas.

Four broad categories of drought are identified as follows; meteorological, hydrological, agricultural and socio-economic drought (Mkhabela et al., 2010). The relationships between these different types of drought are complex. However, common to all types of drought is the fact that they originate from a deficiency of precipitation that result in water shortage for some activity or for some group of people. Meteorological drought occurs when precipitation over a period of time (e.g., weekly, monthly, seasonal) falls below normal while hydrological drought occurs when lack of precipitation leads to shortages of surface and groundwater (Parry et al., 2005; Mkhabela et al., 2010). Agricultural drought occurs when a lack of soil moisture negatively impacts crop yield. Several drought indices based on a combination of precipitation, temperature and soil moisture guides agricultural drought. Heim (2002) wrote that, short-term dryness in the

surface layers which occurs at a critical time during the growing season can result in an agricultural drought that severely reduces crop yields, even though deeper soil levels may be saturated. Thus, agricultural drought can be identified in terms of interval of time, generally in an order of months or years, when the moisture supply of a region consistently falls below the climatically appropriate moisture supply such that crop production or range productivity is adversely affected.

Socio-economic drought occurs when lack of precipitation hinders the economy and socio-political situation in a region. It is associated with failure of water resources systems to meet water demands and thus associating droughts with supply of and demand for economic goods (Mishra & Singh, 2010). When the demand for economic goods exceeds supply as a result of a weather-related shortfall in water supply or associated with elements of meteorological, agricultural, and hydrological drought, socio-economic drought can be identified. In most cases once a meteorological drought sets in hydrological, agricultural and socio-economic drought follows (Mishra & Singh, 2010; Mkhabela et al., 2010). Moreover, the onset of an agricultural drought may lag that of a meteorological drought, depending on the prior moisture status of the surface soil layers. Precipitation deficits over a prolonged period that affect surface or subsurface water supply, thus reducing stream flow, groundwater, reservoir, and lake levels, will result in a hydrological drought, which will persist long after a meteorological drought has ended (Parry et al., 2005). As a natural hazard, drought can cause immense economic and social impact and damage into the atmosphere, environment and the community at large.

The impacts of drought are said to be the world's costliest of all weather related natural hazards, causing an average of 6-8 billion ($US) in global loses annually and collectively affecting more people than any other form of natural disaster (Devereux, 2007; Simelton et al., 2009). For example, the drought related damages in the United State of America from the 1988 large area drought was estimated at $40 billion, which was 3 times higher compared to the estimated loss caused by the 1989 San Francisco earthquake (Mishra & Singh, 2010). Concurrently, droughts are ranked first among all natural hazards when measured in terms of the number of people affects. The reason being that unlike floods, hurricanes, earthquakes, and tornadoes, drought affects water bodies of its resources structures and it seldom results in structural damage (Devereux, 2007). For this reason, the quantification of the impact and the provision for relief are far more difficult for droughts than for other natural hazards. Furthermore, Bond et al. (2008) argue that the consequences of drought are far reaching both for human consumptive uses and for aquatic ecosystems, and serve to highlight several important aspects of its nature, its ecological impacts, and how humans respond to them. It can produce a complex web of impacts that can span many sectors of the society, including economy and may reach well beyond the area in which it is experienced. It is often assumed that these short and long-term impacts and degradation are greatest in regions that are poor (Mishra & Singh, 2010). That is, the impact of drought on rural agricultural production can ultimately reinforce rural labour market problems and cause unrest to the entire rural economic base.

Most of rural economies are dependant of agricultural livelihoods and development, thus severe drought can have a comprehensive and devastating impact on these activities. The most immediate and hard hitting impact drought on rural livelihoods is on crop production (Parry et al., 2005). Drought can undermine farm yields and reduce household food availability, and agricultural income derived from crop sales (Parry et al., 2005; Fraser, 2006; Mkhabela et al., 2010). Drought hinders and put a severe environmental constrain on the process of plants productivity. Its stress reduces leaf size, stems extension and root proliferation, disturbs plant water relations and reduces water-use efficiency (Fraser, 2006). Again it can impact both surface and groundwater resources and can lead to reduced water supply, deteriorated water quality, crop failure, thus reducing a range productive activities (Mishra & Singh, 2010). These entire plant production disturbance ultimately impact on household's food production and security efforts. For example, because of higher dependants of households in rural areas to subsistence food production, severe drought can lead to poor harvests threatening not only agricultural livelihoods but the entire rural food security system (Mkhabela et al., 2010). Drought is the single most critical threat to world food security and because of the anticipated future food demand out of rapid increasing population pressures, it is presumed to become a catalyst of the great food crisis and famines in years to come unless strategies are formulated to minimise its impacts.

It is now accepted that droughts in future pose a threat to climate sensitive economic sectors, specifically agricultural food production, thus a sustainable social and economic development and stability require the efficient and equitable measures to combat the

impacts of drought and to manage water resources (Parry et al., 2005). Hence, the success of drought preparedness and mitigation depends, to a large extent, upon timely information on drought onset, progress and extent through monitoring. In many instances adoption of simple water-harvesting systems (for example, installation of the simplest water-harvesting systems reservoirs and rain water harvesting tanks) and better agronomic practices have increased water availability and access to water at critical times for minimal irrigation (Parry et al., 2005; Mishra & Singh, 2010). However, intensive agricultural irrigation is often found to be inefficient because of water losses which can exceed 50 % in a worse scenario. This kind of intervention can lead to a major problem of rapid evapotranspiration especially where spray/overhead or flood irrigation is used. Night scheduled and drip irrigation is found to be much more efficient to decrease evapotranspiration.

Households and economies that are more diversified are less vulnerable to the direct impacts of droughts, provided that their alternative income sources are neither correlated with rainfall, nor directly or indirectly dependent on agriculture (Fraser, 2006; Mkhabela et al., 2010). Ironically, the costs of this kind of intervention are too high to be afforded by rural households practicing subsistence food production. Other diversification strategies include indigenous forms of soil and water conservation, exploitation of wetter sites, cautious expansion and retraction of cultivated area, and maintenance of distinct seed stocks suited to variable conditions. However, as expected it is only the wealthier households that command the assets necessary to diversify and make investments (Parry et al., 2005). Whether local rural household's food production

strategies work well and whether they harm the environment rather than protecting it clearly depends upon context. In the future an integrated policy is essential not only to increase the water resources capacity and development of appropriate decision support systems for efficient use but also to ensure the implementation of best practice across the entire region in order to promote success food production practices for the households.

2.4. Rural Households' Food Production Systems

Food security is seen as less sufficient global and national agricultural production, and increasingly as livelihoods that are sufficient to provide enough food for individuals and households through their own production (International Food Policy Research Institute (IFPRI), 2002; Stocking 2003; Pretty, Thompson & Hinchcliffe, 2008; Olawepo, 2010). Rural food production systems are usually characterised by poor conditions, small holdings, simple implements are used to cultivate, and land fragmentation is on the increase (Olawepo, 2010). Ayinde et al (2010) wrote that rural households' food production provides the foundations on which transformation of the socio-economic conditions and sustainable food security for the poor can be realised. The attainments of food security assist the household to avoid dependence on external food production channels and food production sources which can be expensive and unaffordable. Thus, rural food production process remains a major source of livelihood to secure food among poor households (Calzadilla, Zhu, Rehdans, Tol & Ringler, 2009; Ayinde et al., 2010). This process which includes amongst others a wide range of subsistence

agricultural activities is also found to act as an option to also contribute to incomes and/or savings, as well as to encourage food diversification in rural areas.

Particularly in developing world, there is predominant activities of small land holders and subsistence farmers whose on-farm and off-farm agricultural inputs and labour provides the main source of food and income (Pretty et al., 2008). In these areas when food production increases the risk of starvation is minimized. Less starvation suggests that individuals become less susceptible to diseases and this makes more labour available for more agriculture activities. However, the process of food production in rural areas has been characterised by very low yields due to agro-ecological features, poor access to services and also lack of knowledge and inputs. Concurrently, Altman, Hart & Jacobs (2009) argue that although an estimated number of about 2.5 million households are engaged in this activity, they do not receive much attention from policy makers. While household production of food is prevalent, there is a need to better understand the opportunities and threats in order to come up with appropriate interventions to support household-level production. Moreover, context-specific support is required to strengthen own production of food, ideally low-cost, low-input and of high nutritional value.

In recent years one of the most identified factors to contribute to slow paced food production process has been the fact that the majority of households depend on rain-fed agriculture for their crops and grazing land for their livestock (Ayinde et al., 2010). That is the availability and reliability of rainfall has accounted for the success and lack thereof

food production process particularly in rural areas. In these areas poor households are unable to afford costly irrigation systems thus losing out on the much needed moisture requirements for their crops to growth (Olesen & Bindi, 2002). In addition, most of these areas particularly in Africa are already hot and vulnerable to global warming and unprecedented climatic conditions. Climate imposes direct constraints on agricultural activities by determining whether or not "there is a sufficient growing season for a particular crop" and enough drinking water for animals (McGregor, 2002: 279). That is, the balance between precipitation and potential evapotranspiration determines the availability of water for plant growth and the combination of water availability and adequate temperature defines the plant growing period. Against such a background, potential unprecedented climatic conditions have inevitably posed a direct and significant challenge to the process of growing crops and livestock in rural areas (Olesen & Bindi, 2002; Gregory Ingram & Brklacich, 2005; Barnett & Adger, 2007). Climate is a key determinant of agricultural productivity and as such, it influences the types of vegetation that can grow in a given location. In other instances issues such as plant diseases and pest infestations, as well as the supply of and demand for irrigation water, are also found to be influenced by climate (Barnett & Adger, 2007). Thus, the key uncertainty for agriculture outlook in many countries is found to be weather and long and short-term climatic condition.

Ordinarily agriculture has always been found to be a complex sector involving different driving parameters such as physical, environmental, economic and social (Miraglia et al., 2009). However, in recent years climate change has been in the forefront of the

negative influences of food production and has caused a huge decline in agricultural production and significantly affecting livelihoods for food security (Gregory et al., 2005). The impact of climate change is drastically fostering a considerable movement into and out of agriculture, suggesting that many households are starting to treat agriculture as a sort of residual activity from which they can seek benefit when it suits them, but abandon when it is inconvenient (Altman et al., 2009). A number of farms are already experiencing shortage of inputs and labour as off-farm incomes become more attractive. Also in many developing countries extreme poverty, low agricultural productivity, and environmental degradation has interacted in a vicious downward spiral to reinforce a decline in food security (Yesuf, Di Falco, Deressa, Ringler & Kohlin, 2008; Calzadilla et al., 2009). Thus intensification of agricultural production for survival has led to natural resource degradation, as desperate poor farmers mine soil fertility and climb the hillsides in an effort to survive. Moreover, it has been difficult for smallholders to plan and develop viable land management and cropping systems to counteract erosion (Barbier, 2000; Yesuf et al., 2008). This has affected the poorest smallholder's farmers especially those who rely on intercropping and relay cropping maize and groundnuts as a means to meeting nutritional needs, maintaining soil fertility and conserving soil.

The most affected groups of famers are women who are practicing agriculture for survival, because they try to create a needed balance between domestic work and food production. Altman et al. (2009) argue that, in rural areas participation in small-plot and subsistence agriculture is way important for food security, with women taking major responsibility for it as one aspect of a multiple livelihood strategy. Women outnumber

men as subsistence producers; this is consistent with the prevalent stereotype of homeland agriculture (Yesuf et al., 2008; Altman et al., 2009). The high prevalence of women in agriculture and particularly in terms of those engaged in semi-subsistence production to supplement household food requirements demands an increased focus on this group and with specific gender determined constraints they face (IFPRI, 2002; Altman et al., 2009). Women also have other domestic roles and responsibilities; namely food selection, food preparation, care and feeding of children, collection of water for hygiene and firewood for fuel. This has impacted dearly on their strength, efforts and time available for household agricultural production. Efforts to enable them to increase the productivity of their time spent on farming activities, and to spend less time on routine household tasks has failed drastically thus it is evident that productivity outputs are minimal in most of women headed households (Altman et al., 2009). One other aspect that has also impacted women in agriculture has been the issues of land tenure. Even though tenure security is not necessarily a sole sufficient condition for improvement in agricultural production and environmental management, secured land-use rights are an essential pre-condition for farmers' sustainable investment in soil improvement and quality. According to Bugri (2008), land resources and the rights to them are fundamental to survival in the developing world, thus, land tenure access resources has been a focus in identifying the causes of Africa's food production and environmental degradation problems.

In order for households to make progress towards maximising food production in rural areas, appropriate support is required to improve the current levels, strategies and to

deal with challenges facing smallholder production (Van Averbeke & Khosa, 2007; Bugri, 2008; Ayinde et al., 2010). Productivity increase is depended on farmers' access to appropriate knowledge and technology. In most developing countries farmers cannot expand cultivation without causing further land degradation, deforestation, and loss of biodiversity (Bugri, 2008). Thus, agricultural development, poverty reduction, and environmental sustainability are likely to go hand in hand when broad-based, market-driven, and participatory and decentralisation of the process is driven by appropriate technological change that enhances productivity (IFPRI, 2002; Van Averbeke & Khosa, 2007). In one way or another, agricultural growth and poverty alleviation should benefit the environment depending on specific social, economic, and agro ecological circumstances (Van Averbeke & Khosa, 2007). However, in most of rural areas farmers are found to continuously produce less quality products. So in order for farmers to improve on food production, the support that they get should be appropriate and dependent on the specific contexts under which a specific smallholder farming is practised. For example extremely poor farmers should get assistance in relation to access to yield-increasing crop varieties, including drought and salt-tolerant and pest-resistant varieties, improved livestock, appropriate tools, fertilizer, pest management, and other yield-increasing and environment-friendly technology (IFPRI, 2002). Such intervention should lead to gradual productivity increases leading to gains in per capita production, reduced unit costs and prices, and increased incomes and purchasing power for low-income farmers and consumers (European Countryside Movement (ECM) 2010; Olawepo, 2010; Thornton et al., 2011). Again these productivity increases should also help to restrain the expansion of agriculture into forests, grasslands, fragile lands,

and wildlife habitats and thereby averted some forms of natural resource degradation. Moreover, these Smallholders should not adopt recommended conservation measures and agricultural technologies uniformly, but have to experiment, adapt and improve them within be compatibility of their existing farming practices and systems but also such should be affordable for sustainability purpose (ECM, 2010). Thorough training of these poor households and farmers is also needed in order to avoid environmental problems such as increased soil salinity and lowered water tables in irrigated areas, human health problems due to excessive pesticide use, and water pollution and soil degradation resulting from inappropriate use of farming inputs (IFPRI, 2002; ECM, 2010). These trainings should introduce poor farmers to participate in growing global markets to produce reliably safe goods of a predictable quality and high-value such as horticultural produce, fish, livestock, and processed foods (Olawepo, 2010; Thornton et al., 2011). Against this background it is important to look closely to two types of food production processes in rural areas which are livestock farming and crop production.

2.4.1. Livestock Farming in Rural Areas

Livestock farming as a means of food production is common amongst households in rural areas. There is a rapid Intensification of livestock production which is widely advocated to meet the increasing demands for its products to contribute towards improving the livelihoods of many of rural households (Khan & Usmani, 2005; Calzadilla et al., 2009; Udo, Aklilu, Phong, Bosma, Budisatria, Patil, Samdup & Bebe, 2011). In recent years there has been a significant change in livestock production systems

worldwide. Production of meat, milk and eggs products has been a major driving force for these changes. The increasing demand for animal source food has helped many smallholder crop and livestock farmers to engage in some market-oriented economic activities by intensifying their livestock production practises (Udo et al., 2011). For example, even though the economic crisis of 2008 was expected to slow down the growing trend of livestock production, in emerging and developing countries it was expected that the growth in consumption of animal products will remain strong. One of the noticeable advantages of livestock farming is that animals can cope with the changing meteorological parameters more easily than crops because of their mobility and ability to adapt to different surroundings and to different feed (Ayinde et al., 2010). Thus, intensifying the potential of smallholder animal production systems to contribute on the improving the livelihoods of the poor households in rural areas. It is evident particularly in developing countries that the demand for livestock products is largely met primarily through production in the country where these products will be consumed (Khan & Usmani, 2005; Calzadilla et al., 2009; Udo et al., 2011). In many of these countries, rural poor households are found to be earning a higher share of their income from livestock production than other larger-scale forms of farming. Again this process also contributes towards household subsistence needs in many ways; for example, slaughtered goat provides meat for home consumption, while other animals such as chickens may produce eggs.

The type of livestock kept by household producers varies according to agro-ecological conditions of region they are based and can also relate to tradition, resources, family life

cycle and wealth status (Udo et al., 2011). A large proportion of rural households particularly in Africa keep poultry in their farmyard. According to Ayinde et al. (2010), growing of livestock such as chickens and other birds in rural areas is less costly to acquire and maintain; hence, they are easily slaughtered for immediate consumption within the household. Again, these kinds of animals survive solely on scavenging; possibly being fed with some kitchen scraps and very little attention is given to health care or management. Poultry can provide food, a small cash income, and they can play a symbolic role in hospitality, in exchange and in sacrifice. The other main benefits derived from household and/or village poultry would be income from sale of eggs and sale of birds, followed by egg and meat consumption in the family (Khan & Usmani, 2005; Calzadilla et al., 2009). The other most common animals reared by households in rural areas include cattle, buffaloes, sheep, goats and pigs. Traditionally, animals such as cattle are kept as draught animals with milk as a by-product and buffaloes as dairy animals.

There is a diverse of challenges facing livestock farming in rural areas (Calzadilla et al., 2009). Hence, in recent years the increase in livestock production is found to be occurring mainly outside the traditional rural sector. Most rural areas do not meet the requisite preconditions for livestock production, especially grazing land and pastures for animal feed. In this regard, climate change is proving to be one of the contributors to worsen these challenges (Muchenaa, Ondurua, Gachinib & de Jagerc, 2005). The effects of climate change on livestock have been direct, in such as the link of stress factors (e.g. high temperature) on livestock appetite. Some of the indirect influence of

climate changes has seen an intense modification of the quantity and quality of forages from grasslands (Muchenaa et al., 2005; Miraglia et al., 2009). Without proper and optimum feeding, animals do not produce up to their production potential (Khan & Usmani, 2005; Calzadilla et al., 2009). Increasing temperature because of climate change also implied the potential of increase in animal diseases due to the shift of pathogens to more favourable host environments (e.g. multiplication of pathogens in animal feed). The most common animal diseases experienced in rural areas are internal parasite, rabies, indigestion and also foot/mouth disease (Khan & Usmani, 2005). With all these constrain to raise livestock, many households have either focused more on crop production or diversified their food production processes.

2.4.2. Aspects of Crop Production in Rural Areas

Crop production is one of the major and most practiced food security livelihoods in rural areas; however, it has been diminishing in recent years. Recently, crop production in rural areas has been characterised by very low yield due to lack of irrigation supplements, limited use of fertilizers and other climate related complications (Calzadilla et al., 2009; Tshiala & Olwoch, 2010; Rowhani, Lobell, Linderman & Ramankulty, 2011). For example, the poor productivity of African agriculture is the reflection of its comparatively low input use. Very little of cropland area (6%) is irrigated in Africa. Fertilizer use is also sparse, averaging only around 18 kg per hector of cropland; whereas average fertilizer usage is much higher in other developing regions, and has increased since the early 1980s, the rate of application on Africa's cropland has hardly

changed (Barbier, 2000). Crop production is rain-dependent in most of rural areas and when rain is scares the households usually have minimal harvesting (Barbier, 2000; Tshiala & Olwoch, 2010). The productivity of this practice which is mostly subsistence has been less of a success leading to high prevalence of hunger and malnutrition in rural areas. The problems associated with household crop production are reinforced by the fact that farmers with low incomes and few resources have continued their unsustainable cropping activities which deplete soil fertility, causes erosion and environmental degradation (Heerink, 2005). Some of the major food crop produced by households includes maize, sorghum, potatoes, beans and vegetables. These products are produced by households and smallholder farmers with the intention of either home consumption and/or sale in the local markets (Rowhani et al., 2011). However, one of the major challenges to limit the efforts of these farmers has been the issue of land.

According to Food and Agriculture Organisation (FAO) (2006) access to land is a crucial factor in the eradication of hunger and poverty in the rural area. However, to secure enough land for crop production is frequently not easy and constitutes a complex process in these areas. Hence, limited availability of land is a major concern. Such a limitation has been hindering success to crop production process. Majority of households in rural areas relies on small piece of land that households own in their backyard and in most cases such land is already degraded because of mismanagement and over-cultivation (Olesen & Bindi, 2002). Again the issue of land has been traditionally linked to social identity and the right to land have been used as a political exploitation of tension, and the ownership of land is concentrated in the hands of

minority, whether based on class or ethnicity (Barbier, 2000; Olesen & Bindi, 2002; FAO, 2006). These scenarios disadvantage the poorest households in the rural areas, because of their low class, limited connection and contribution to the local traditional authority. Most of the household in the rural areas own less that 0.5 hector of land and producing enough crops to secure enough food to survive throughout dry seasons has been a nightmare (Calzadilla et al., 2009). For example, Calzadilla et al. (2009) further wrote that African agriculture tends to be mainly extensive in its use of land, and as land that is already low in productivity becomes degraded, households tend to continue trying to reap benefits on such land or seek to secure an alternative rather than investing on improving and maintaining the nutrient inputs on the available one. Investments in soil maintenance and water conservation structures has been difficult particularly to the poorest households in rural areas

Unprecedented climatic conditions have also contributed excessively on the limited success of crop production in rural areas. According to Olesen & Bindi (2002), the crops produced by households particularly in rural areas are vulnerable to excessive heat that ultimately destroys them. With an increase in use of less improved seeds, pest attacks and weed infestation, the heat and drier soil conditions in these areas increase the vulnerability of crops to wind erosion and evapotranspiration. Also, low use of fertilizer across Africa is a major cause of concern, both from the food production and environmental perspective (Rowhani et al., 2011). The crops are significantly affected by climatic variables because photosynthetically active radiation, air temperature and water are the driving forces for crop growth (Abraha & Savage, 2006). Meteorological

variables, including rising temperatures, changing precipitation regimes, and increased atmospheric carbon dioxide levels are some of the critical elements affecting these crops. Moreover, Calzadilla et al. (2009) highlighted that the increase in atmospheric carbon dioxide concentration and changes in associated climatic variables will likely have a major influence on regional as well as international crop production and ultimately on food security in rural areas.

2.4.3. Food Security Prospects

In recent years, food security has been subjected and heavily tied to market forces that are prejudiced by the socio-economic and political conditions of the society in which they live (Stocking, 2003; Misselhorn, 2005; Pretty et al., 2008; Thornton, Jones, Ericksen & Challinor, 2011). Moreover, the increasing world population's demand of food as well as changing eating habits in emerging markets has created strain on households with less access to economic opportunities in these countries. Ironically, the socio-economic and political conditions are found to be hostile in rural areas and have left the majority of poor people suffering from hunger and starvation. Even though the link between poverty, income and household food security is not clear, households with limited access to income and whose own food production process is less successful are found to be more vulnerable to food insecurity (Hendriks, 2005; Misselhorn, 2005; FAO, 2006; Jacobs, 2009). Pretty et al. (2008) wrote that, agriculture is a key to food security in many parts of the world. It contributes to poverty alleviation by reducing food prices, creating employment, improving farm income and increasing wages. However, in recent

years, households that engage in own-production are found to be less food secured unless such households are engage in own-production as an additional livelihood strategy for income and food security.

The depth of food insecurity varies within and between households. The status of a household and its members is very sensitive to livelihood shocks and stressors. For example, according to Thornton et al. (2011) the rapid food price inflation during 2007-2008 economic crisis, considerably increased the number of food insecure people from 900 million to more than 1 billion globally. Hence, more chronically food insecure and low income households were found to be more vulnerable to higher food price shocks during this time. In this context, households which might have been marginally food secure before this shock might have fallen into severe transitory or severe chronic food insecurity afterwards, placing increased pressure on both social aid and protection during this time (Mtika, 2001; IFPRI, 2002; Rosegrant & Cline, 2003; Stocking, 2003). Furthermore, Stocking (2003) argues that, with these inevitable socio-economic challenges, the majority of rural communities particularly in the tropics and subtropics have been experiencing a decline in household food access and consumption, with sub-Saharan Africa and parts of Latin American, the Caribbean and central Asia suffering worse. In other instances, people's ability to acquire food and gain access to and control of production resources has remained a biggest obstacle to achieve food security for all in rural areas (Pretty et al., 2008). The quest to address the social factors surrounding food security had serve as a window through which observation about complexities and challenges from competing structures of production and consumption emerged

(Misselhorn, 2005; Pretty et al., 2008). Some of the causes and influences of inadequate food access have been extreme poverty, environmental stressor and climate change.

Climate change through its diverse impact on agricultural productivity has continued to threaten food security and safety particularly in developing countries (Gregory et al., 2005). Some of the most visible impact of food insecurity has been severe and/or chronic lack of adequate nutrition and lack of sufficient micro-nutrients to children leading to malnutrition and malnourishment, irreversible changes in child development, poor cognitive development, weak educational performance, increased risk of morbidity and impaired immune functions (Altman et al., 2009). In order to deal with these kinds of problems, Pretty et al. (2008) suggest the strategic intensification of households' own food production. Making agriculture work should be central to policy approach for food insecurity reduction and increasing economic growth (Speth, 1993; Allen, 1999). Moreover, increased investment in small-scale and subsistence agriculture will help redress the inequalities in food access and security. Empowering people to grow their own food for subsistence or income generation will provide nourishment and potential income to many people in rural areas. Furthermore, according to Misselhorn (2005), increased in productivity of agricultural activities can also help to slow the pace of rural-to-urban migration and offers farmers incentives for conserving the natural resource base upon which future agricultural production depends.

2.4.4. Challenges of Food Production and Security

The ability of agricultural production to provide for and support the growing population has been a concern for generations and continues to be a number one priority on the global policy agenda (Thornton et al., 2011). The challenges associated with this sector are immense, and have threatened the production based resources in a form of loss of water through contamination, loss of genetic resources, habitats and species, adverse impacts of pesticides, weeds and insects. Hence, in most of agro-ecosystems, declining crop yield is exponentially related to loss of soil quality through climate related problems such as drought and floods (Speth, 1993). Also, HIV and AIDS has currently been found to be a perpetuating factor that is unique, slow-moving and devastating shock that strips households food production and livelihood assets as a creeping emergency that progressively erode the lives and livelihoods of the affected household (Speth, 1993; Rosegrant & Cline, 2003; Stocking, 2003; Gregory et al.,2005). Other significant constrain associated with food production is high cost of crop damage due to poor or non-existing storage facilities, with Spoilt fruits and food crops being common feature, and increased water scarcity.

The HIV and AIDS epidemic is another global concern, in addition to its direct health, economic and social impacts, the disease also affect food production, security and nutrition. Adult labour is often removed from affected households and these households are left with less capacity to produce or buy food (Hendriks, 2005). Concurrently, HIV and AIDS had add to disinvestment by families in farming activities and a move towards

livelihoods strategies more adaptable to unstable and insecure circumstances which are previously associated with political and economic instability and conflict, together with poor financial resource and poverty. In other words, HIV and AIDS is a shock to households' food security and the latter cannot be properly understood without considering its effect. While the immediate, devastating effects are at the individual level, the consequences are much broader, for instance, from the intolerance strains on traditions and the child fostering mechanism, to extreme pressure on health systems and also loss of productive labour (Mtika, 2001; Hendriks, 2005). Moreover, Mtika (2001) argues that the disease contributes to psychological strain including depressed families, stress, suicide, isolation, self-pity, stigma and hatred had affected household's abilities to sufficiently producing their own food.

Climate change is one of the most important stressor which affect food systems of many rural areas in several ways which range from direct effects on crop production (for instance, changes in rainfall leading to drought or flooding, or warmer or cooler temperature leading to changes in the length of growing season) to changes in markets, food prices and supply chain infrastructure (Rosegrant & Cline, 2003; Barnet & Adger, 2007; Brahmbhatt & Christiaensen, 2008). In warmer or tropical environment , climate change have resulted in more intense rainfall events between prolonged dry period, as well as reduced or more variable water resources for irrigation. Such conditions have promoted pests and diseases on crops and livestock, as well as soil erosion and desertification. Particularly in rural Southern Africa, the short and long-term climate and environmental stressors are found to be endemic to the food production livelihoods and

practices (Speth, 1993). Hence, many rural households' food systems had failed to deliver food security because the related determinants and/or the links between them are disrupted by climate change and other climate related stressors. Two categories of occurrence (natural and human processes) namely flood and droughts are virtually universally accepted to be the primary indicators of climate change. Barnet & Adger (2007) stated that, flood and drought had continuously destabilized the poor household's food production, clean water, energy supply and environmental health, amongst others.

2.4.5. Measures to improve food production and security

The goal of achieving improved food production and security in the decades ahead emerges as one of the greatest challenges humanity has ever faced (Rosegrant & Cline, 2003). Agriculture outputs should be increased and people should have the income to buy them. That is, food security which commonly includes food supply, access, adequate utilization, and safety and in some cases cultural accessibility of food for all people at all times has to be a priority in the global food agenda (Speth, 1993; Duhaime & Godmaire, 2002; Rosegrant & Cline, 2003; Hendriks, 2005; Pretty et al., 2008; Gregory et al., 2005). In other words, food security is seen to exist when all people , at all times, have physical and economic access to sufficient, safe, nutritious food to meet their dietary needs and preference for an active and healthy life. According to Hendriks (2005) in order to achieve improved food production and security, there is a need to a radical policy and investment reforms on multiple fronts, including human resources, agricultural research, rural infrastructure, water resources, community based

agricultural and natural resources management (Rosegrant & Cline, 2003). These policy reforms which should be progressive in nature must not only increase agricultural production in a larger scale but also facilitate household own production, boost income and reduce poverty in rural areas where most of the poor live. Hence, in countries with heavy dependence on agriculture, progress towards improved reforms will not only depend on making agriculture more productive in a national scale but also it will require an intervention at the local small-hold farm practice and significantly at the household level.

One aspect which is making improved food production a requirement to the alleviation of hunger in third world countries is the global increase in food prices (Rosegrant & Cline, 2003). These increases which are coupled by the amplified poverty rate are threatening household food security by reducing the purchasing power and available resources for purchasing food and eroding income. Furthermore, Duhaime & Godmaire (2002) stated that, continuing rising of food prices and heavy reliance on food purchases increase vulnerability to food insecurity as greater reliance on wage income discourages home production of food. Improved food production will mean that, the combination of three elements of food securities are merged, for instance, human resource (people) should be available, production should flourish and access should be maintained and facilitated (Hendriks, 2005). Food access indicators include food entitlement and socio-economic indicators that specify ability of household to cope with various stresses induced by economic and social change. Most food security outcome indicators measure more than food consumption for example, malnutrition indicators

also capture the influence environment aspects, bio-utilisation factors, health and sanitation on nutrition, growth and development (Rosegrant & Cline, 2003).

The improved production of food is the first pillar of food security; hence food security is a basic human right. Failing to attain these human right may not necessary capture all dimensions of poverty, but it may indicate it as an important indicator of wellbeing (Hendriks, 2005). Improved food security will mean improved systems of food production, distribution and economic access to cope with climate change. Moreover, subsistence food production is strongly influenced by the availability of water. The majority of poor households are situated in places with limited water and they are likely to have limited food production because they are not able to irrigate their crops during dry seasons. Again, Gregory et al. (2005) stated that achieving food security will require more than improving productivity and profitability while minimising environmental impact, it also focus on goals of households food security and sustainable agriculture. This process requires that the focus is not only on the aggregate supply of food but also on income and land distribution at household livelihoods and dietary needs. Concurrently, the requirement for improved food production will have to increase substantially over the next few decades to feed increasing global population and that measures should be established in order to deal with environmental problems affecting the majority of households in rural areas.

2.5. Environmental Challenges Facing Poor Households' Food Production

Environmental conditions in rural areas play a major role in determining the ability of households to produce their own food (Morvaridi, 1998; Barbier, 2000; Ramoliya, Patel, Pandey, 2004; Bugri, 2008; Titilola & Jeje, 2008). Because of limited economic opportunities many households in rural areas are still dependent of subsistence farming to meet their daily food requirements. According to Ye & Ranst (2009), the gap between rural and urban income remains wide, and inequality in the rural economy has remained high since the mid-1990s. Moreover, the continuous cultivation of crops under the mounting pressure of an ever-growing population has resulted in various forms of soil degradation including, among others, water and wind erosion, fertility depletion, physical deterioration and salinization. In practical terms, poor people endured degraded environments, to which they often contribute further degradation (Blaikie, 1985; Ramoliya et al., 2004). These people often destroy their immediate environment by cutting down forest, their livestock overgraze grassland and they overuse marginal lands to produce food for survival. This situation has meant that, natural resources becomes under increasing pressure in rural areas, threatening health and development of food production and security (Bugri, 2008). Furthermore, Swinton & Quiroz (2003) argued that, degradation of natural resources is rampant in many resource-poor areas of developing countries, particularly those areas with fragile soils, irregular rainfall, and high population concentration. Agricultural food production which forms a major part of food security in rural areas has suffered a major blow in these areas.

Degradation of land, forest and wetland resources has extended the depth and breadth of deprivation in many of rural areas. For example, according to Muchenaa, Ondurua, Gachinib & de Jagerc (2005), a global Assessment on soil degradation estimates that 65% of African agricultural land of which 31% is permanent pasture land, and 19% is forest and woodland is degraded. In particular, Sub-Saharan Africa is identified as the only region in the world where per capita food production has been on the decline for the last two decades. Moreover, the land which is meant for cultivation in this region is found to lack the ability to provide quantitative or qualitative goods and services either as a result of natural and human-induced changes, soils erosion and land pollution (Barbier, 2000; Muchenaa et al., 2005). Ironically, environmental problems in rural areas are in one way or another reflection of the interrelationships among resource change, human productive activities and the accompanying transformations of people's lives (Morvaridi, 1998; Barbier, 2000). In other words environmental problem can logically be understood as a situation in which human action affects natural environment and resources in pursuit of their welfare, income and livelihood. In this sense environmental problems are automatically social problems (Swinton & Quiroz, 2003; Ramoliya et al., 2004). It is a common understanding that all organisms modify their environment, and humans are no exception, however, as the human population has grown and the power of technology has expanded, the scope and nature of human modification has increased drastically (Ramoliya et al., 2004; Muchenaa et al., 2005). Humanity's increasing capacity to manipulate nature has over the years been a cornerstone of the development process (Barbier, 2000). That is, human actions have transformed nature through technology and labour to the extent that it has become impossible to separate

the two. Swinton & Quiroz (2003) wrote that, the ability of human beings to manipulate nearly every aspect of the natural world has challenged the notion that nature is somehow separate or autonomous from human culture.

It is now evident that the global consequences of human activity are not something to face in the future, but something that the humanity is dealing with already (Ramoliya et al., 2004). The changes which are observed in the environment are on-going, and in many cases acceleration can seemingly be traced to a disparate phenomenon of a growing scale of the human needs and enterprise. According to Vitousek, Mooney, Lubchenco & Melillo (1997), the rates, scales, kinds, and combinations of changes occurring now are fundamentally different from those at any other time in history. Human domination syndrome is changing the earth more rapidly than it can be understood. Hence, the momentum of human population growth, together with the imperative for further economic development in most of the world, reflects that the domination will increase in years to come (Vitousek et al., 1997). In particular, the use of land to yield goods and services represents the most substantial human alteration of the earth system (Vitousek et al., 1997; Swinton & Quiroz, 2003). Human's use of land alters the structure and functioning of ecosystems, and how ecosystems interact with the atmosphere, with aquatic systems, and most other components of global environmental change. For example, the economic fortune of most developing countries, including Nigeria, revolves, largely around the exploitation and use of land resources especially in the primary industry such as agriculture (Titilola & Jeje, 2008). The importance of land to agriculture and rural development is well recognized. Thus

many developing countries' natural and human resources constitute the principal economic assets for development and reduction of poverty. Unlike in advanced and industrialized countries, the function of land as a production resource is still very crucial (Ramoliya et al., 2004). Thus, land plays a pivotal role in the efforts to maintain food access and economic growth to cater for the growing human population in terms of agricultural practices.

Consequently, in most of developing country access to land has always been a thorny issue. For example, in many parts of East Africa, access to land is granted under diverse arrangements with different degrees of tenure security (Ramoliya et al., 2004; Muchenaa et al., 2005). With secured land tenure household has been encouraged to invest in land improvements, especially when such improvements are associated with high initial cash and non-cash capital investments (Muchenaa et al., 2005). However, in systems of shared property land has been subjected to systematic over-use and degradation of natural resource base. Muchenaa et al. (2005) wrote that permanent land title deeds encourage investment in land, even though it does not necessarily solve all problems associated with land degradation. In African countries for instance, many scholars has continuously blamed poor agricultural production and environmental degradation leading to extreme hunger, environmental refugees and lack of socio-economic progress on land tenure systems applied. In many countries of this region, tenure systems applied have communal characteristics that lack the security required for stimulating investments in agriculture for enhanced productivity and sustainable land resource use (Bugri, 2008). The other major environmental challenge on food

production in rural areas stated by Olesen & Bindi (2002) is access to water. Subsistence food production is strongly influenced by the availability of water. The majority of poor households are situated in places with limited water and they are likely to have limited food production because they are not able to irrigate their crops during dry seasons. Olesen & Bindi (2002) also asserted that water scarcity has emerged as the most constraining factor for food security in many regions and it will still be in the future, with a special negative impact on rural women and children. Rain-fed agricultural food production is the only option they have; hence, with the current evidence of limited rains and extreme drought their efforts have been compromised.

In recent years, rural agricultural production has been characterized by a significant amount of land degradation and conversion. Poor farmer's desperate and unsustainable practices to increase productivity have left the farming land less appropriate for efficient farming practices (Morvaridi, 1998). Lack of and misuse of modern farming inputs on agricultural land has been a major challenge faced and causing natural resource degradation. Hinrichsen (2000) wrote that while natural resource degradation is often a consequence of poverty, it has also contributed extremely to the increase of deprivation in rural areas. This downward spiral has been found to be more prevalent in many locations where low-income people reside (Hinrichsen, 2000; Ramoliya et al., 2004). Poverty, economic pressure, high rates of population growth, insecure land tenure, agricultural mismanagement of soil and water resources, and lack of agricultural intensification, deforestation, overgrazing and shifting cultivation are widely claimed as responsible for land degradation. In Africa for example, major causes of soil degradation

were reported as overgrazing (49%), agricultural mismanagement (28%), deforestation (14%) and overexploitation of vegetation for domestic and industrial use (13%) (Muchenaa et al., 2005). Furthermore issues such as loss of vegetation cover through deforestation are seen as major causes of land degradation (Muchenaa et al., 2005).

Other causes of degradation include poor agricultural production caused by lack of finance, poor soil fertility, inadequate and unreliable rainfall, pests and diseases, inadequate farmlands, bush burning and excessive tree cutting. Hinrichsen (2000) argued that limited service provision in rural areas is instigating the overuse and exploitation of natural resources by the poor who are trying to meet their present needs particularly through subsistence agriculture. Majority of rural households desperately continue with their cropping practice in an inherently infertile soil without adequate application of combined organic and inorganic inputs thus leading to production yield decline and deterioration of soil chemical properties (Muchenaa et al., 2005). Because the crops lack the nutrients required for growth, they consume only a small proportion of the water and the remainder is lost through run-off, soil evaporation or drainage. This process is also exacerbated by the kind of farming practices and their natural resource setting. For instance, most poor rural households practice food production in mountainous land and hilly regions which are vulnerable to soil degradation (Olesen & Bindi, 2002). Such places are mostly dry, open and vulnerable to erosion either when it is windy or when there are floods and with over-cultivation, soil exhaustion inevitably occurs (Olesen & Bindi, 2002). Water erosion is a generalised problem in nearly all tropical mountainous areas. Furthermore, Nyssen, Poesen & Deckers (2009) wrote that

mountain agriculture systems are predominant in rural areas and are vulnerable to environmental change for various reasons, such as the cost of accessibility and infrastructure as well as the limited opportunity for production gains associated with scale of operation.

Different kinds of degradation can be observed and identified in rural areas. Resource depletion that encompasses a problem of aquifer exhaustion, soil fertility, mining, soil erosion, deforestation and over grazing is the most prevalent form of degradation in these areas (Bugri, 2008). According to Scherr & Yadav (1996), displacement of soil material through erosion is irreversible although the long term effect depends on the productive capacity of the depth and quality of the soil remaining. However, with over-cultivation, the soils reach a critical point at which even with any inputs applied productivity no longer increases. In most of the agricultural land soil erosion has caused a loss of the fertile layer of topsoil in which food crops are supposed to grow. For instance, Ramoliya et al. (2004) started that the soil in the semiarid and arid regions is particularly vulnerable to soil degradation by erosion and salinization. The unsuitable, over intensive agricultural practices have exacerbated this problem and in the case of severe degradation this has led to desertification (Scherr & Yadav, 1996; Nyssen et al., 2009). Through factors such as reduced plant cove for example, topsoil is removed by wind and water. Also the loss of soil quality through pollution with heavy metals and acid from mines and power stations can also be identified (Titilola & Jeje, 2008). Desertification is a major cause of losing the fertile topsoil necessary for plant growth. This is because when rangelands lose their vegetation cover through over-grazing and

deforestation the soil become exposed to either water or wind erosion. Unfortunately, when the soil nutrients are being depleted through crop removals, leaching and soil erosion in rural areas farmers have been unable to sufficiently compensate the loss by for example replenishing soil nutrients via crop residues, manures and mineral fertilizers (Scherr & Yadav, 1996; Rozelle, Huang & Zhang). Thus soil fertility is increasingly recognised as a major biophysical cause of stagnant per capita food production in most of Sub-Saharan African countries.

There has been an increasingly dwindling on vegetation cover in rural areas because majority of households cut down trees for fuel wood without replacement. For example, in South Africa there is a major problem of deforestation caused by a heavy use of trees for construction, herbal medicine and fuel (Titilola & Jeje, 2008; Ye & Ranst, 2009). The majority of rural households still use firewood for energy despite the implementation of different electrification projects. It is estimated that, if unchecked, and at the current rate of harvesting, trees will ultimately disappear from communal areas of South Africa within 20 years to come (Titilola & Jeje, 2008; Ye & Ranst, 2009). Thus, destroying the habitats of numerous creatures in the wild and contributing to soil depletion and erosion. Worldwide, nearly one-third of cropland has been lost due to erosion during the past 40 years and continues to be lost at a higher rate.

There are many challenges and problems associated with the high rate of environmental degradation particularly in rural areas of the third world countries

(Hinrichsen, 2000; Ramoliya et al., 2004). For instance the multiple decades of economic reforms in Africa have not resulted in the anticipated growth in per capita agricultural production of most of the countries (Heerink, 2005). Declining output fertiliser price ratios, particularly for food crops, contributed to soil fertility depletion and agricultural stagnation. Globally, a staggering 70% of all dry lands have already been classified as degraded. This represents 14% of the earth's land surface area and Africa is the worst affected continent, as 73% of its agricultural dry lands are thought to be degraded (Titilola & Jeje, 2008). The number of people affected is vast, for it is estimated that more than 70% of Africa's 500 million people depend directly on the environment for their livelihoods. Furthermore close to 60% of the ecosystem service examined in the millennium ecosystem assessment of 2005 were found to be degraded or used in ways that cannot be sustained (Titilola & Jeje, 2008). Nyssen et al. (2009) observed that, whereas onsite impacts of land degradation are immediately felt by the farmers the overall impact is much wider than the sum of individual losses or benefits. In many instances, farm sizes, especially in the high-potential areas, have been reduced to the point where adequate living can only be obtained if land is farmed intensively and if there is an off-farm income as an option (Muchenaa et al., 2005). Many poor farming households have abandoned their existing degraded pasture and cropland, and invading new lands for grazing and cultivation (Titilola & Jeje, 2008; Nyssen et al., 2009). But because these farmers lack access to additional investments in soil conservation, and because of ultimate overgrazing and cultivation their production process do not last long until they abandon the newly invaded land and move on.

The increasing pressures on agricultural land have also resulted in much higher nutrient outflows and subsequent breakdown of many traditional soil-fertility maintenance strategies and the opening of new lands (Muchenaa et al., 2005). Concurrently, households have resorted into removal of vegetation between cropland, conversion of forest and woodlands on steep slopes into rangeland and marginal arable land in order to extend the production practice (Hinrichsen, 2000). This challenges that are faced in rural areas reflect the interrelationship among resource change, human productive activities and the accompanying transformation of people's lives (Rozelle, Huang & Zhang, 1997; Hinrichsen, 2000; Olesen & Bindi, 2002). Most of local environmental problems such as desertification in Africa and air pollution in South Asia are of more immediate relevance and pose serious challenges to the sustainability of food security in these areas (Koninga & Smaling, 2005). Also, the population pressure increases has fostered a decline on people's access and ability to settle in a highly agricultural potential areas with fertile soils, adequate rainfall and mild temperatures. Many people are dominating marginal areas with less fertile soils, extremely variable and unpredictable rainfall, fragile soils, frequent crop failures and limited resources for improving livelihoods. In most of developing countries access to both organic and inorganic agricultural inputs has been a challenge (Koninga & Smaling, 2005; Muchenaa et al., 2005). Heerink, (2005) wrote that for example in Africa, both organic and inorganic agricultural fertilisers are used very inefficiently. Also, as Olesen & Bindi (2002) indicated, the high rate of population without the improvement of the standard of living, provision of services and employment has posed a threat and contributed to the deteriorating environmental conditions in rural areas. With the continuous cropping

without the use of external inputs, topsoil organic matters which are a good proxy for soil productivity have declined.

In order to arrest land degradation, reliable data should be generated and contextualisation of degraded land within the biophysical environment should be established, taking its causes and impacts within broader livelihood strategies and poverty-related issues (Rozelle, Huang & Zhang, 1997; Hinrichsen, 2000; Olesen & Bindi, 2002; Heerink, 2005). That is, farmers should develop flexible management decisions about the allocation of scarce resources and available technologies to a limited range of options in their environment, as well as addressing temporal and spatial dimensions associated with land constraints. Also, robust social institutions and resource sharing arrangements to insure against adversity should be considered in some of the regions (Hinrichsen, 2000; Olesen & Bindi, 2002; Koninga & Smaling, 2005). For example, in chronically land degraded regions such as East Africa; improvement should be considered within the wider set of choices facing rural households about the allocation of resources, where they can best invest labour and capital and how they can make choices to reduce risks (Muchenaa et al., 2005). Successful adoption of these improvements will have a huge impact on the reduction of problems of deforestation due to reduced agricultural expansion, land degradation and erosion, climate change (due to increased vegetative cover and carbon sequestration), desertification and biodiversity decline.

Improved land management, poverty reduction and agricultural development are critically related goals for rural areas in the third world, and must be treated as such in the design of better policies for economic development and poverty alleviation (Barbier, 2000; Hinrichsen, 2000). It is evident that soil degradation has an immense negative impact on the productive capacity of soil. However, there should be a considerable investment to modern technologies by different governments for land intensification and improved livelihoods, such as inorganic fertilizers, irrigation and draft power to provide a much needed relief in rural areas. Koninga & Smaling (2005) argue that, most types of soil degradation can be prevented or reversed for example by adding nutrients to depleted soil and rebuilding top soil through soil amendments. However, without government intervention such options are not available to the poor households in the rural areas.

2.6. The Effects of Climate Change on Households' Food Production

It is now evident that climate change emerged as one of the most challenging aspect humankind has to face and will still battle with for many years to come (Blaikie, 1994; Parry et al., 2004; Abraha & Savage, 2006). Through different indicators such as floods, drought and heat waves for example, climate change has affected many households particularly in rural areas. The vulnerability context of these households has left them unable to cope and recover after an event of a natural hazard occurred (Blaikie, 1994; Parry et al., 2004; Abraha & Savage, 2006; Prandini, Toti, van den Born, Vespermann, 2009). Consequently, Rowhani et al. (2011) argued, major changes of a worldwide

nature are now taking place that will have profound influence on the earth and its people in the next decades. Climate change is a reality and its adverse effects are already witnessed in most developing countries, where populations are most vulnerable and least likely to easily adapt to these changes. Most of these countries' social, institutional and physical infrastructure's capacities are not strong enough to cope with the short and long term impacts of climate change (Prandini et al., 2009). For example, the geographic location in the tropical and subtropical regions where crops are exposed to a near maximum temperature tolerance and where dry land, non-irrigated agriculture dominate, is causing a huge decrease on production yields even from a small change in the climate.

Climate change is deepening poverty and indirectly exposing poorest countries and their communities to the greatest risk of food insecurity (Parry et al., 2004; Abraha & Savage, 2006). The higher temperatures and changing precipitation levels resulting from climate change are depressing crop yields and causing limited harvest especially in most low-income countries, where adaptive capacity is low (Parry et al., 2004; Abraha & Savage, 2006; Molua, 2009). Molua (2009) emphasised that the issue of climate change is important for most of developing countries because of their highly dependence on agrarian economy. In essence, for these countries, agriculture does not only provide for food but together with the forestry sectors caters for employment of the majority of the population, contribute significantly to national incomes, and remain the driving force for economic development (Parry et al., 2004). Thus, these developing nations are facing a greater vulnerability because of their reliance on agriculture, lower

tolerance to coastal and water resource changes, and limited financial, technical, and institutional capacity to adapt (Banuri & Opschoor, 2007). Furthermore, the tropical are particularly vulnerable to potential damage from environmental changes because large areas of these regions are already covered by poor soils, which have already made much of the land unusable for agricultural production (Khandlhela & May, 2006). For instance, in Africa and Latin America, an extreme decrease in overall agricultural productivity of up to 30% is projected during the next century.

Again, due to different effects of climate change, developing countries are also likely to suffer huge economic losses. However, beyond the direct economic impacts, crop failure due to climate change could increase unemployment, destabilise food security further increase competition for scarce resources, and increased social inequality. Banuri & Opschoor (2007) argued that, on a national level, vulnerability to economic losses manifests in poorer countries due to a lack of resources and capacity to respond to the threats and ultimately impacts of climate change. The ability to adapt and cope with weather and climate change related hazards depends on economic resources, infrastructure, technology, and social safety nets availability in any affected country (McGuigan, Reynolds & Wiedmer, 2002). And because many poor countries are already under pressure from issues such as population growth, rapid urbanization and resource depletion, stagnant economic growth, poverty and hunger, climate change comes as one of many environment problems that they are already confronted with (Parry et al., 2004; Banuri & Opschoor, 2007; Hahn et al., 2009). In the community level, issues such as class, gender, ethnicity, age, level of education and access to resources are also

found to be the determinants of vulnerability to climate induced natural hazards and disasters (McGuigan et al., 2002). Because of lack of servings, security and insurance, for the poorest households in rural areas it is almost impossible for them to replace or compensate for the numerous things that they lose or are destroyed, including houses, livestock, food reserves, household items and tools during climate induced floods for example.

Depending on the geographic area, the effects of climatic changes have also altered soil conditions and element availability so severely that the tolerance and adaptation capacity of certain plant species to new or chemically imbalanced growth media has been overwhelmed (Hickey & Salas, 1995). Furthermore, the change of climatic conditions has been identified as having potential for increasing bacterial contamination of food and water, which consequently may result in alteration of the types, frequencies, and intensities of crop and livestock pests, change of risks related to water and foodborne infection diseases. Because of temperature increases pest's infections and damage are common during the critical and most sensitive earlier stage of crop development leading to crop failure (Tshiala & Olwoch, 2010; Rowhani et al., 2011). Consequently this failure is also reinforced by generally deteriorating quality of soils and in some cases landslides and erosion phenomena. Increased temperature and altered precipitation patterns have resulted in increased losses of soil minerals, especially by leaching and erosion.

The incidents of crop failure are common in rural areas. Miraglia, Marvin, Kleter, Battilani, Brera, Coni, Cubadda, Croci, De Santis, Dekkers, Filippi, Hutjes, Noordam, Pisante, Piva, Prandini, Toti, van den Born, & Vespermann (2009) wrote that, crop failure has decreased yields of spring-sown crops such as maize, sunflowers, and soybean. Higher temperatures and a greater incidence and intensity of extreme weather have led not only to significant modifications in crop systems and yield, but also to an expanding range of crop pests and altered transmission dynamics of challenges, which has exacerbated the yield reduction and impair food safety (Hahn et al., 2009; Miraglia et al., 2009). For example, the increase of temperature is found to limit crop yield by accelerating the plant development, affecting the floral organs and fruit formation and the functioning of the photosynthetic apparatus (Tshiala & Olwoch, 2010). Climate change effects on many rural situations will also influence the decrease in the amount of yearly precipitation, prolonged dry periods and projected temperature increases (Khandlhela & May, 2006; Hahn et al., 2009; Miraglia et al., 2009),. This process will ultimately alter and enforce a faster growing periods and shorter lifecycles. And if the timing and length of growing seasons is shifted, possible alteration of the planting and harvesting dates will change reinforcing the need to change crop varieties used in a particular area. Unfortunately, many households do not have resources and inputs to cope when these changes are occurring. Moreover, such household are vulnerable to hunger and malnutrition.

Again, it is evident that the effects of climate change are clearly linked to food production, food access and food distribution among households in rural areas (Olesen

& Bindi, 2002). However, the severities of these effects are identifiable among households who are solely land-dependant for food production and income (Hahn et al., 2009). The vulnerability of rural households and small-holder subsistence farmers can also greatly influenced by lack of seeds availability during planting season. According to Khandlhela & May (2006) increased events of extreme climatic conditions which disrupt and destroy harvest has also impacted on the availability of seeds to plant. Again the disruption of seeds stores by natural events such as floods is common in rural area. The effects of flood include the disruption of food crops on farms, dying of livestock through different diseases, and again disruption of seeds stores (Hickey & Salas, 1995; Khandlhela & May, 2006; Hahn et al., 2009). The significance of flood damage can be ecological were flood wash away the fertile soil that household food production relies; however, the impact on food crops can be more severe, particularly if floods are experienced just before harvesting period, because that would jeopardise seeds supply for the following year food production seasons(Hickey & Salas, 1995; IPCC, 2001). Moreover, efforts by households to seek seeds from other family members and friends are found to be less effective, because such people could be facing the same problem.

Climate change has a significant impact on agriculture and forestry in rural areas thus forcing producers to adopt new practices in response to altered conditions. According to the intergovernmental panel on climate change (IPPC), the analysis on climate change impact shows that because of drought, there is a general reduction of potential crop yields and a decrease in water availability for agriculture and population in many parts of the developing world (IPCC, 2001; Khandlhela & May, 2006). Drought is not only

undermining farm yields, killing animals and reducing household food availability but also is influencing poor harvesting and that has automatically threatens food security and livelihoods in rural areas. Furthermore, drought has also contributed to long term agricultural stagnation and deepened rural poverty, because of destroying land which is the source of food production (Heerink, 2005). The process of drought is closely linked to erratic and unprecedented rainfall accompanied by excessive heat and temperatures (Khandlhela & May, 2006). Thus, this relationship is mostly affecting those households that are only dependent on their own food production to survive, in particular those who depend on rain-fed agricultural activities for food security and income generation.

Small-scale family farms, traditionally the backbone of much of developing country agriculture, are under threat, while globalization and domestic investments are encouraging production on a larger scale (International Food Policy Research Institute (IFPRI), 2002). The nature of farming is changing rapidly in many developing countries because of the aging farm population, the feminization of agriculture, the growing labour shortages and depletion of asset bases resulting from the HIV and AIDS crisis, and the decreasing cost of capital relative to labour (Altman et al., 2009). Furthermore, the complexities surrounding the effect of climate change on household food production illustrate the challenges involved in trying to deal with the growing need of ensuring food security in rural areas. Government support structures to solve the problem of food insecurity in rural areas should take into account the uniqueness of the complexities faced by food producers in their respective areas (IFPRI, 2002; Altman et al., 2009 Miraglia et al., 2009). According to the Miraglia et al. (2009), in order to deal with

emerging food safety risks caused by climate change, a large variety of disciplines are needed ranging from natural to social science and, as a consequence, a holistic approach is advisable to adequately tackle the complexities encountered. Climate change threatens farm yield and returns. Thus, any agricultural policy to be adopted must therefore bring innovative approaches to production and rural institutions in order to play an important role in influencing the sector's ability to adapt successfully to climate change (IPCC, 2001; Khandlhela & May, 2006; Hahn et al., 2009). This strategy calls for all agriculture decision makers to take into account and understand the influence and sensitivity within which climate change aligns to production processes particularly in rural areas.

2.7. Household Climate Change Adaptation Measures

Local small-holder and substance farmers adoption of different adaptation measures such as changing crop variety, adopting soil and water conservation measures, harvesting water, planting trees, and changing planting and harvesting periods are found to be apparent to those whose activities are rain dependent amid recent erratic rainfall experiences (World Bank, 2000; Nordhagen & Pascual, 2012; Zhou & Turvey, 2014). In other words the integration of scientific and traditional knowledge to adaptation have helped to provide efficient, appropriate and time-tested ways of advising and enabling processes to deal with climate change to be effective. Moreover, such processes are not only enabling farmers to cope with the adverse effects of climate

change and variability, but are also increasing the agricultural productivity of poor farm households.

Other measures of adaptation include non-yield related which include migration and shift of farming practices from crop production to livestock herding or other sectors. However, there are many significant adaptation challenges that are distributed unevenly across and within regions (Zhou & Turvey, 2014). These challenges are reinforced and linked to the multi-factor inequalities and underdevelopment scenarios particularly in rural areas of developing countries (UN, 2007; Jabareen, 2013; Zinyengere, Crespoa & Hachigonta, 2013; Kirezieva, Jacxsens, Van Boekel & Luning, 2014; Van Dijk, Van Rooij & Hilderink, 2014). Challenges such as inadequate socio-economic infrastructure, limited skills, poverty and limited resources are among the factors which render households to be vulnerable to climate change activities and unable to adapt to changing conditions. It is noticeable that the war against climate change goes beyond households low scale adaptation measures and challenges. Hence, developing countries need to incorporate and integrate climate change issues into their broader socio-economic development strategies (UN, 2007). In other words climate change should not be dealt with in vacuum apart from other development challenges (Van Dijk et al., 2014). Developing countries should strive for measures to increase and build capacity for successful adaptation. Consequently, developing countries need international assistance to support adaptation in the context of national planning for sustainable development, more capacity-building and transfer of technology and funds (Zinyengere et al., 2013; Kirezieva et al., 2014). In other words, any effort to fully

engage developing countries in the international climate regime should provide investment and technology flows toward climate-friendly development and such must take account of circumstances and trends that shape present development patterns and condition possibilities for the future of the country in question.

Funding for adaptation in developing countries must be sufficient and sustained looking at the extreme levels of vulnerability in these countries. Furthermore, assessing the impacts of and vulnerability to climate change and subsequently working out adaptation needs requires good quality information (Nordhagen & Pascual, 2012; Zhou & Turvey, 2014). This information includes climate data, such as temperature, rainfall and the frequency of extreme events, and non-climatic data, such as the current situation on the ground for different sectors including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity, and coastal zones (UNFCCC, 2007; Nordhagen & Pascual, 2012; Zhou & Turvey, 2014). To achieve this process, a sure knowledge base from systematic observation and forecasting services is essential. For example, monitoring trends of sea surface temperature and sea level are essential in order to assess their impacts on the increased intensity of tropical cyclones and storm surge; monitoring events relating to the phenomenon of El Niño Southern Oscillation (ENSO) is important in helping determining its effects on reducing or increasing precipitation in different regions leading to both floods and drought (Zinyengere et al., 2013). Another important adaptation strategy is economic diversification within sectors to reduce dependence on climate-sensitive resources, particularly for countries that rely on narrow ranges of climate-sensitive economic activities, such as the export of a

climate-sensitive crop (UNFCCC, 2007; UN, 2007). For example, coffee in Uganda, a vital source of income for the country, will suffer drastic reduction in suitable growing areas under climate change. The realization that developing countries have very different individual circumstances and that the specific impacts of climate change are dependent on the conditions experiences as well the geographical, social, cultural, economic and political situations should be taken in to consideration. That is, countries requirement for a diversity of adaptation measures very much depend on individual household's circumstances and specific effects encountered.

2.8. Conclusion

This chapter has demonstrated that the challenge of achieving sustainable development cannot be underestimated, thus it requires a substantial transformation of the present economic development models, equivalent to the transition economies underwent with the industrial revolution of the growth-focused development paradigm (Ortiz and Cunning, 2011; Glemarec and De Oliveira, 2012). Further, it proved that the ecosystem has continued to be the victim of massive market and intensive economic growth (Ericksen et al., 2009). Indeed, the costs of the environment degradation are persistently ignored by economic and development strategies and the negative impacts of these failures are felt hardest by the most vulnerable groups particularly in rural areas. In this context, this chapter pointed out from a theoretical perspective that the effects of climate change which include land degradation, loss of biodiversity, change in hydrology and change in climate patterns which are believed to be resulting from

enhanced anthropogenic emissions of greenhouse gasses seem to have a serious consequence on food production and food security. The chapter showed that the people who are extremely affected by these changes are the vulnerable groups living in rural areas. Consequently, the international community is at locker heads to find global solutions to curb the effects of climate change. that is, the establishment of institutions which are meant for facilitation and integration of global climate change efforts such as United Nations Framework Convention on Climate Change (UNFCCC) by the United Nations and the Intergovernmental Panel on Climate Change (IPCC) has shown the seriousness of the need to deal with the issues of climate change through both mitigation and adaptation processes. The international experiences of climate change on food production are dealt with in the next chapter.

CHAPTER 3

CLIMATE CHANGE EFFECT ON FOOD PRODUCTION: INTERNATIONAL EXPERIENCES

3.1. Introduction

The international debates and discourses about the aspects of climate change driven policies have unfortunately focused on the question of which countries should be held responsible for reducing the effects of climate change rather than a collective effort towards dealing with the problem. On one hand, some scholars argue that industrialized countries are obligated to do the most to avoid climate change because their emissions have caused most of the increase in greenhouse gas concentration to date. Whereas on the other hand some commentators reflect that developing countries account for a large and growing share of emission and that no climate policy will succeed without significant participation by these countries. Both these arguments are important to consider, however, neither has a realistic basis for designing a policy that sovereign nations will have to ratify and to implement. The lack of consensus between developed and developing countries on issues of climate change has left majority of people vulnerable to natural hazards such as floods, drought and heat waves (Aerts, van Asselt, Bakker, Bayangos, van Beers, Berk, Biermann, Bouwer, van Bree, de Coninck, Dorland, den Elzen, Gupta, van Heemst, Jansen, Kok, Nabuurs, Veraert & Verhagen, 2004; United Nations Framework Convention on Climate Change (UNFCCC) 2007; Leggett, 2009; Urquhart, 2014). Though climate change is increasingly recognized as a significant problem in both developing and developed countries, its course remains

remote from the core of national and international policy-making (UNFCCC, 2007). For example, the tension between developing and developed countries was still visible at the recent 2014 annual United Nations Climate Change Conference (UNCCC) of parties (COP20) in Lima Peru. The conference concluded in the early hours of Sunday morning 14 December 2014 which was more than 24 hours beyond its scheduled time because of the fierce arguments on the agreement which should be reached at another conference in Paris France in 2015 on how to deal with climate change beyond the year 2020. In this instance, even though negotiators from about 196 countries patched together a compromise which kept the show on the road towards to a new global climate agreement in Paris, the arguments left almost everyone unhappy with one element or another. For instance, developing countries wanted these contributions to include plans for adaptation to climate change as well as emissions cuts, and for developed countries to include financial support for poorer nations, whereas, developed countries wanted all countries to provide standardised information on their emissions targets and plans, to ensure transparency and comparability. Leggett (2009) argue that, under a business as usual scenario, greenhouse gas emissions could raise by 25-90% by the year 2030 and the Earth could warm by 3°C. This change will have serious effects on crop yields particularly in tropical areas leading to increased risk of hunger, spread of climate sensitive diseases such as malaria, and an increased risk of extinction of about 30% of all plant and animal species (UNFCCC, 2007). For instance, changes in rainfall pattern are likely to lead to severe water shortages, flooding and soil erosion and also rising temperatures will cause shifts in crop growing seasons which affects food security. Thus, hundreds of millions of people may remain food insecure, millions of

children may die from malnutrition, and environmental degradation may continue unchecked.

This chapter deals with three main issues which are relevant to the understanding of the international experiences, interactions and deliberations about climate change and its impact in different facets of life, particularly the issue of household food production in rural areas. The first section of the chapter will deliberate on the role of different international institutions aimed at addressing and formulating climate change policies and strategies, for instance, institutions such as the United Nations (UN) and Intergovernmental Panel on Climate Change (IPCC). These institutions played an important part in the formulation of the Kyoto-protocol and the United Nations Framework Convention on Climate Change (UNFCCC) which are two of the most important international channels for deliberations and implementation of climate change related strategies. The second section of this chapter narrates different continental climate change effects and experience. Such will include different levels of adaptation methods which are adopted by different countries guided by the kind of climate change effects they are facing. The last section of this chapter will deliberate on specific measures of mitigation and adaptation which need to be taken into consideration if climate change effects were to be dealt with.

3.2. The Role of International Institutions and Conventions on Climate Change

There is growing recognition of the lead role been played by the United Nations, and it's Secretary-General Ban Ki-moon on finding solutions to some of today's toughest challenges, including the food crisis and climate change. At the recent 2014 climate change conference in Lima Peru, the secretary general reiterated the need for leaders from government, business, finance and civil society to crystallize a global vision for low-carbon economic growth and to advance climate action on five fronts which include cutting emissions; mobilizing money and markets; pricing carbon; strengthening resilience; and mobilizing new coalitions. Even before, the United Nations (UN) commitment to issues of climate change became more visible when it established its framework conversion on climate change (UNFCCC) (1994) and a collaborative establishment together with World Meteorological Organization (WMO) of the Intergovernmental Panel on Climate Change (IPCC) (1988). The IPCC was meant to constantly provide governments with a clear view of the current state of knowledge about the science of climate change, potential impacts, and options for adaptation and mitigation through regular assessments of the most recent information published in the scientific, technical and socio-economic literature worldwide (UNFCCC, 2007). Its assessment depended primarily on observed changes in surface temperature and climate model analyses, more recent assessments including multiple lines of evidence for climate change. Moreover, the first line of evidence in assessing climate change was based on careful analysis of observational records of the atmosphere, land, ocean and cry sphere systems. However, on the other side the establishment of the UNFCCC, provided a platform to a variety of policy formulation aimed at addressing climate

change, both at international and national levels, and with a purpose to facilitate adaptation as well as mitigation which are both connected to the Kyoto protocol where duties of all the states are listed.

The Kyoto protocol was initiated at the third Conference of Parties (COP3) in 1997. It was essentially the first step to lay a ground on what needed to be done to tackle climate change. Firstly, it attempted to reinforce a commitment by rich developed and industrial countries on an aggregated emission reduction target of 5% by 2008-2012 and which was sought to be the first commitment period (UNFCCC, 2007). Again the protocol advanced for flexibility systems in which these rich countries could cooperate with others, particularly developing countries on how to achieve climate change targets using the clean development mechanism (CDM). However, many critics argued that because of its less strict and non-binding agreement, Kyoto protocol became inadequate (Aerts, et al., 2004). For example one of the world largest emitter of climate change induced greenhouse gases the United State of America was not on board when the protocol was formulated. Furthermore, developing countries were excluded in any of the commitment of the future emissions because of the recognised urgent need for economic growth and development in these countries.

The establishment of the UNFCCC by the United Nations again provided a basis for concerted international action to mitigate climate change and to adapt to its impacts. Its provisions are found to be far-sighted, innovative and firmly embedded in the concept of

sustainable development (UNFCCC, 2006). In 1994 after its inception the UNFCCC constituted 191 member states which became committed to launch national strategies for adapting to expected impacts, including the provision of financial and technological support to developing countries, and to cooperate in preparing for adaptation to the impacts of climate change. All Parties to the UNFCCC were also found to be committed to submitting national communications in which they outlined the implementation of the conversion and the impacts from climate change that they were facing. The communication channels among the member states were designed to allow countries to provide information on assessments of vulnerabilities and adaptation options. Although knowledge of how best to do adaptation was still in its infancy, the Parties of the UNFCCC increased their support for action on adaptation (Aerts, et al., 2004; UNFCCC, 2006). This includes the development of national adaptation programs by some developing countries including least developed countries, and their integration into national strategies. Water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity, and coastal zones were found to be the common sectors for which impacts and vulnerability assessment have been carried out by these countries. Additionally it projected investment flows and financing relevant to the development of an effective and appropriate international response to climate change and estimated that by 2030 developing countries will require an estimated amount of US$ 28-67 billion in funds to enable adaptation to climate change (UNFCCC, 2006). The UNFCCC also publishes variety of articles on issues of climate change, its dangers and the need to commit towards its elimination. The most cited one is the article 2 of the UNFCCC which highlights the key risks and potentially severe impacts of

climate change emanating from dangerous anthropogenic interference with the climate system. Furthermore article 2 emphasises, propose and reinforce the conversion ultimate objective which is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (UNFCCC, 2006). Article 2 states that such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner, thus recognizing the importance of the nexus between sustainable (economic) development and climate protection (UNFCCC, 2006).

The relationship between sustainable development and climate protection has been more emphasised at the UNFCCC workshops organised in different regions of the international community. For instance, at the Africa's workshop, participant emphasised and agreed that systematic observation networks in their region are inadequate because there is a lack of stations and lack of maintenance (UNFCCC, 2007). The important information for measuring the impact and adaptation opportunities to climate change are lacking in this side of the planet. In other words missing and scattered observational climate data in Africa is a big constraint to understanding current and future climate variability, and such a missing link is said to be toxic on the quest towards achieving sustainable and economic development (Leggett, 2009; UNFCCC, 2007; Urquhart, 2014). In this regard, the participants at the workshop underlined the crucial need to implement the climate information for development needs action plan for Africa aimed at improving the inadequate and deteriorating observing systems through an

integrated program that includes not only observations, but also climate services and climate risk management and policy (UNFCCC, 2006; UNFCCC, 2007). At the workshop in Asia participants highlighted a wider scale need of improvement of observation and data availability which include in islands, mountainous, and coastal ecosystems, at the national, regional and global levels (UNFCCC, 2007). Also efforts regarding the harmonization and consistency of data which need to be enhanced through improved coordination between data providers from different sectors were emphasised. For example at the workshop, China reported an improvement it is making to its systematic observation network under the framework of the China Global Climate Observing System (GCOS) program (UNFCCC, 2006; UNFCCC, 2007). The country uses the system to monitor atmospheric composition, energy balance, water and carbon cycles, ecosystems, land use, ice and snow, and regularly submits real-time observation data its national stations to the World Data Centre for Meteorology (UNFCCC, 2006; UNFCCC, 2007). Furthermore, China has an operational system of short-term climatic monitoring, prediction and assessment, established in the Beijing Climate Centre, and has some regional cooperative climate programs with other Asian developing countries such as the Islamic Republic of Iran, Nepal, Sri Lanka and Uzbekistan (UNFCCC, 2007). In Latin America UNFCCC workshop, participants reported that climate information is either unavailable or sparse, and it is difficult to use it for modelling and scenario development (UNFCCC, 2007). One of the main challenges emphasised which is leading to a large gap in observational coverage is the fact that network of national correspondents works only on a voluntary basis (UNFCCC, 2006). It was reported that the websites of national meteorological services, in general,

do not make datasets available to allow studies of detection and attribution of climate change and there are just a few countries in Latin America which, at present, have active climate change programs (UNFCCC, 2006; UNFCCC, 2007). In Small Island developing state climate observations is a responsibility of the national meteorological and hydrological services. Furthermore the Pacific Islands Global Climate Observing System has been at work addressing capacity-building needs, improving observing stations, climate prediction, telecommunication and data rescue (UNFCCC, 2007). For example, Regional Action Plan for Central America and the Caribbean is partly being implemented through the Mainstreaming Adaptation to Climate Change project (UNFCCC, 2007). This process includes upgrades of observation networks, data rescue, and assessment of surface and groundwater monitoring networks (UNFCCC, 2006). The overall progress and reportage at the workshops as underlined by the UNFCCC is that there is a dire need for vulnerability and adaptation assessments in order for countries to evaluate and implement proper responses to climate change (UNFCCC, 2006). As it was clearly stipulated, a major problem in all regions was the limited capacity at regional and national level due to deficiencies in data collection and the lack of technical expertise. It was highlighted as important to make the models, tools and methodologies that are appropriate for assessments available particularly in developing countries where the impacts of climate change are found to be more devastating (UNFCCC, 2007). However, with limited access to technology, skills and resources to develop the socio-economic conditions of the poor in these countries, the ability to minimise the effects of climate change is still a huge challenge (UNFCCC, 2006).

3.3. Overview of Climate Change in Developing Countries

The current perception is that climate change activities are not yet prominently featuring well in the environmental and policy agenda of many of developing countries even though they are the most vulnerable to the effects of climate change than any other. Many developing countries are said to still regard climate concerns as no more than potential barriers to their ability to reduce poverty and increase income levels (Leggett, 2009; UNFCCC, 2007; Urquhart, 2014). Most developing countries are said to be ignoring the fact that the future effects of climate change will be severe if they do no formulate proper adaptation methods (Leggett, 2009). For instance, it is predicted that climate-related decreases in food security and increased malnutrition are rated as high risks in Africa, Asia, Central and South America under current levels of adaptation, should global mean temperature increase by 4°C (UNFCCC, 2007; Urquhart, 2014). Furthermore, it is estimated that billions of people particularly those found in developing countries face a shortage of water, food and greater risks to health threats as a result of climate change in the next decade (UNFCCC, 2007). Such a situation will have a devastating effect on the quest for achieving the goals of sustainable development and also the United Nations Millennium Development Goals (MDGs) (UN, 2007). Interestingly, even though it might not appear in most of developing countries environmental and policy agendas, many of these countries' farm households are already adopting some adaptation methods in response to the perceived long-term climate changes effects (Urquhart, 2014). In these countries, particularly those which are largely dependent on agricultural activities and which are already facing climate

change challenges, governments have given adaptation action a high or even urgent priority (UNFCCC, 2007; Urquhart, 2014).

The adoption of adaptation measures such as changing crop variety, adopting soil and water conservation measures, harvesting water, planting trees, and changing planting and harvesting periods are found to be assisted some of the farmer on their subsistence farming activities particularly the ones which are rain dependent amid recent erratic rainfall experiences (Urquhart, 2014). Other measures of adaptation include non-yield related which include migration and shift of farming practices from crop production to livestock herding or other sectors (UNFCCC, 2007). However, it is safe to say that the war against climate change goes beyond households' low scale adaptation measures. Developing countries need to incorporate and integrate climate change issues into their broader socio-economic development strategies (UNFCCC, 2007). In other words climate change should not be dealt with in vacuum apart from other development challenges (UNFCCC, 2007). Developing countries should strive for measures to increase and build capacity for successful adaptation (UNFCCC, 2007). Consequently, developing countries need international assistance to support adaptation in the context of national planning for sustainable development, more capacity-building and transfer of technology and funds (UNFCCC, 2007; Urquhart, 2014). In other words, any effort to fully engage developing countries in the international climate regime should provide investment and technology flows toward climate-friendly development and such must take account of circumstances and trends that shape present development patterns and condition possibilities for the future of the country in question (UNFCCC, 2007).

Furthermore, the realization that developing countries have very different individual circumstances and that the specific impacts of climate change are dependent on the conditions experienced as well as the geographical, social, cultural, economic and political situations should be taken into consideration (Leggett, 2009). That is, countries' requirement for ~~a~~ diversity of adaptation measures very much depend on individual circumstances and specific effects encountered. It is already evident that the consequences of climate change affect almost all countries either developed or developing in one way or another. What matters is the capacity within which a particular country can cope and adapt to the after-effects of the climate change they are facing.

3.4. Regional Outlook of Climate Change Effects and Measures of Adaptation

Climate change in the 21st century is a worldwide recognized issue for most regions of the planet, notwithstanding the fact that the causes of this change are still a matter of debate. Consequently, the effects of climate change are found to be diverse from one regions or continent to the other (UNFCCC, 2007; Urquhart, 2014). Furthermore, because on unequal socio-economic progress among different countries, it is evident that even countries within the same region can be found to be affected differently by the effects of climate change. In continents such as Africa, which is highly dependent on agricultural activities, not only for food security but also for economic growth, the biggest effects of climate change have been through the extreme episodes of drought and limited rainfall (UNFCCC, 2006). Whereas in North America and some of the Asian

countries, climate change effects has accelerated and reinforced growing incidents of hurricanes, raising in sea levels, tsunamis and wildfires.

3.4.1. Africa

It is public knowledge that historically and even currently; Africa has made negligible and insignificant contribution to the growing stock of greenhouse gases in the atmosphere (Collier et al., 2008). Actually, it was estimated in 2003 that in terms of relative contributions to emissions, North America and Europe contributed 55% of total greenhouse gas emissions, while Asia and Pacific Island states contributed 37% (Downing, Ringius, Hulme & Waughray, 1997; Collier, Conway & Venables, 2008; Institute for Security Studies (ISS), 2010). The remaining shared 9% of the emission was contributed by the other regions other that those mentioned above including Africa. Consequently, this scenario reflects that climate change is not a problem of Africa's own making, yet almost all parts of the continent stand to be particularly hard-hit because of its geographic location, agricultural dependence, challenges in adaptation. A broad scientific and political consensus has been established that climate change poses a considerable threat to Africa, its ecosystems and many of its species (ISS, 2010). Current higher temperatures, the drying up of soils, increased pest and disease pressure, shift in suitable areas for growing crops and livestock, increased desertification, floods, deforestation, and erosion are all signs that climate change is already happening and represents one of the greatest environmental, social and economic threats facing Africa (Collier et al., 2008; ISS, 2010). Unless decisive actions

are taken to deal with this problem, the continent will witness catastrophic consequences including rising sea-levels, droughts and famine, and the loss of up to a third of the world's plant and animal species (Collier et al., 2008). Different levels of vulnerability in the continent are attributed to the consequences of the manifestation of climate change and such are already having negative effects on the region's ability to cope with the challenges (Collier et al., 2008; ISS, 2010).

The most obvious factors which are exacerbating the vulnerability of the African continent to consequences of climate change is that of high levels of poverty, illiteracy and lack of skills, weak institutions, limited infrastructure, lack of technology, weak water systems and also high dependence on agricultural production for food security (Downing et al., 1997; Collier et al., 2008). For instance, direct effects on agriculture are varying widely across the continent, with some areas (for example, eastern Africa) predicted to get wetter and much of southern Africa getting drier and hotter (UNFCCC, 2007; Collier et al., 2008; ISS, 2010). The overexploitation of land resources including forests, increases in population, desertification and land degradation is also posing additional threats to agricultural systems (Collier et al., 2008). Furthermore, the effects of climate change are hitting hard on Africa's economy due to the fact that agriculture in the region is the largest single economic activity accounting for around 60% of employment and, in some countries, more than 50% of Gross Domestic Product (GDP) (UNFCCC, 2007). For example, West Africa is one of the most vulnerable areas to climate change due to its historical propensity to drought and desertification, its dependence on subsistence agriculture, and its vulnerability to poor rainfall (Collier et

al., 2008). It is estimated that one third of African people already live in drought prone areas and 220 million are exposed to drought each year (UNFCCC, 2007; Collier et al., 2008). The effects of climate change are found to be adding salt to the wound in the African continent and the episodes of hunger and starvation have been increasing in recent years due to climate change induced disasters (Collier et al., 2008).

There are a variety of more visible impacts of climate change which have led African population to battle with the aspects of food production and security for many years now (Collier et al., 2008). For instance, reduced crop productivity has been associated with heat and drought stress with strong adverse effects on regional, national and household's livelihoods and food security (UNFCCC, 2007; Collier et al., 2008). For example, it is reported that, climate change manifestation through drought has caused a general decline in most of the subsistence crops such as sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; millet in Sudan; and groundnuts in Gambia (UNFCCC, 2007; Collier et al., 2008). Furthermore, Africa has faced increasing water scarcity and stress with a subsequent potential increase in water conflicts as almost all of the 50 river basins in Africa are trans-boundary (Ashton, 2002; De Wit & Jacek, 2006). The fact that most of African Agricultural production relies mainly on rainfall for irrigation, drought will hit hard on subsistence farmers and most of the agricultural land will be lost, exacerbating shorter growing seasons and lower yields (UNFCCC, 2007). Most of Africa's water (85%) is used in agriculture, which is highly sensitive to climatic fluctuations, with a low intensity of cultivation, little irrigation, low yields and stagnant or declining food production (UNFCCC, 2007; Collier et al., 2008). It is estimated that

about 75–220 million people will face more severe water shortages by the year 2020 because of drought (UNFCCC, 2007; Collier et al., 2008). The vulnerability to extreme impacts of climate change in Africa has been reinforced by the weak institutional networks and low levels of adaptation options (Collier et al., 2008). However, the majority of countries in this region are taking the fight against climate change very serious.

The fact that almost all African countries have ratified UNFCCC and supported the Kyoto protocol reflects the commitment that these countries have on issues of climate change. For instance, Kenya is one of the countries which have adopted a climate change policy together with an establishment of a national committee on climate change dedicated to research, analyze and recommend measures to be adopted in order to diversify and minimize the impacts of climate change in the country (Ashton 2002; De Wit and Jacek 2006; Collier et al., 2008). Other African countries such as South Africa have also formulated climate change response strategies which are driven and facilitated at the highest levels of governance to show commitment (De Wit and Jacek 2006; Collier et al., 2008). This reflection is apparent even though Africa's role in emissions of carbon is typically minor and that the future projections still suggest that it will continue to be marginal (De Wit and Jacek 2006). In other words the current visible effects of climate change in Africa have created a space within which the continent is forced to try and devise decisive measures of adaptation in order to avoid apparent food insecurities in areas where poverty is already rife (Collier et al., 2008). However, shortage of skills, technology and weak institutional coordination is found to be derailing

the efforts by many countries in Africa to deal with climate change (De Wit and Jacek 2006; Collier et al., 2008). Hence, devastating future climate change projections are made for Africa (Collier et al., 2008).

It is predicted that concerning temperatures, higher warming throughout the continent and in all seasons, compared with global average, are expected in the near future to lead to more drier climate at the subtropical regions (De Wit and Jacek 2006; UNFCCC, 2007; Collier et al., 2008). Major decrease in annual rainfall in much of Mediterranean Africa and the northern Sahara is expected to be apparent while East Africa is expected to experience increased annual rainfall resulting to flooding (Ashton 2002; De Wit and Jacek 2006). It is again estimated that agricultural production will severely be compromised due to loss of land, shorter growing seasons, and more uncertainty about what and when to plant (De Wit and Jacek 2006; UNFCCC, 2007). Worsening of food insecurity and increase in the number of people at risk from hunger are predicted (UNFCCC, 2007). Yields from rain-fed crops could be halved by 2020 in some countries (De Wit and Jacek 2006; UNFCCC, 2007). Net revenues from crops could fall by 90% by 2100 and already compromised fish stocks will be depleted further by rising water temperatures (Ashton 2002; De Wit and Jacek 2006). Concerning health, alteration of spatial and temporal transmission of disease vectors, including malaria, dengue fever, meningitis, cholera will be experienced in most of the African countries (Collier et al., 2008). Furthermore, in coastal zones, threat of inundation along coasts in eastern Africa and coastal deltas, such as the Nile delta and in many major cities due to sea level rise, coastal erosion and extreme events (Ashton 2002; De Wit and Jacek 2006). The effects

of climate change in the lives of communities in Africa seem to be more adverse that any other regions in the world; however, a continent such as Asia is found to be a vulnerable as one can imagine because of the high population densities and high levels of poverty and inequality (UNFCCC, 2007).

3.4.2. Asia

In terms of space and even population numbers, Asia is found to be largest region on earth and spreads over four climatic zones which include boreal, arid and semi-arid, tropical and temperatures (Muralia & Afifib, 2014). These geophysical features of Asia has rendered it to be the most vulnerable continent facing formidable climatic, environmental, and socio-economic challenges more than any other region in the world (Kameyama, Sari, Soejachmoen & Kanie, 2008; International Fund for Agricultural Development (IFAD), 2009; Muralia & Afifib, 2014). Already in most of Asian countries, manifestation of climate change has created barriers and stumbling block on government's efforts to reduce poverty and thus reversing many important socio-economic gains made throughout the years (IFAD, 2009). Prominent increases in the intensity and frequency of many extreme weather events such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, tornadoes, snow avalanches, thunderstorms, and severe dust storms are experienced in the region (IFAD, 2009). For instance natural hazards, such as the 2004 Indian Ocean Tsunami, the 2005 Pakistan Earthquake, and the 2006 landslides in the Philippines left most of the socio-economic infrastructure and networks destroyed and thus perpetuating high levels of poverty and

hunger (IFAD, 2009; Muralia & Afifib, 2014). Just like in Africa climate change is posing serious threat to poor farmers and rural communities who live in remote, marginal areas such as mountains, dry lands and deserts of Asia (Muralia & Afifib, 2014). These areas are found to have limited natural resources, communication and transportation networks and also weak institutions (IFAD, 2009; Muralia & Afifib, 2014). Furthermore, in these areas land and most of the ecosystems are degraded, water and air quality are deteriorating while continued increases in consumption and associated waste have contributed to the exponential growth in the region's existing environmental problems (Kameyama et al., 2008). For example, increasing water stress arising from extreme temperature and high levels of El Nino have caused a huge decline in rice production in many parts of Asia (IFAD, 2009; Muralia & Afifib, 2014).

Other impacts of climate change in Asia include increased flood damage to infrastructure, livelihoods, and settlements, heat-related human mortality increased and drought-related water and food shortage (IFAD, 2009; Muralia & Afifib, 2014). For example, it is estimated that Asia alone account for over 91% of the world's total death and 49% of the world's total damage due to natural disasters in the last century (Kameyama et al., 2008). Furthermore, the extreme weather events in China during the year 2006 included major storms and flooding in the east and south, as well as heat and drought in central, western and north eastern regions killed more than 2700 people and caused $20 billion in damages (IFAD, 2009). Most of this damage has been in agricultural activities which are found to be the main source of livelihood for most rural people in the region and also the human activity most affected by climate change

(Kameyama et al., 2008). For example in South Asia, agriculture is extremely vulnerable to climate change because of high levels of poverty in the area, low human development indices, inadequate legal and governance mechanism, and vulnerability to extreme weather events (UNFCCC, 2007; Kameyama et al., 2008). In recent times, climate change has instigated a huge decline in crop yield by reducing soil moisture for many parts of Asia putting many millions of people at risk from hunger (Kameyama et al., 2008). One of the reasons for this vulnerability has been that much of the region is adapted to, and thus reliant upon, the annual monsoon occurrence, which leaves it vulnerable when the monsoon fails and rainfall is significantly limited (UNFCCC, 2007; Kameyama et al., 2008). However, for those in the coastal regions the experience has been of extreme flooding which damages infrastructures and disturbed most of the coastal livelihoods among the poor (UNFCCC, 2007).

For most of coastal areas of Asia, climate change is found to be affecting the majority of people through tropical cyclones and their associated high winds, storm surge, and extreme rainfall (UNFCCC, 2007; Kameyama et al., 2008). For instance, most of the people who live in the South Eastern coastal regions of Asia are affected by climate change-related hazards (UNFCCC, 2007). These low-lying coastal areas are more sensitive to the effects of sea-level rise and storm surge and thus have potentially more to lose from climate change than landlocked nations (Kameyama et al., 2008). For example, a significant portion of the deltaic country of Bangladesh gets flooded on a yearly basis (UNFCCC, 2007; Kameyama et al., 2008). That is, about 21% of the population which account for about 30 million out of the 130 million Bangladeshis, who

live in coastal area and who are poor are being affected by the manifestation of climate change through these natural events in a constant basis (UNFCCC, 2007; Kameyama et al., 2008; IFAD, 2009). Furthermore, the melting of glaciers in the Himalayas has increased the risk of flooding, erosion and mudslides in Nepal, Bangladesh, Pakistan, and north India during the wet season (IFAD, 2009). This eventuality is occasioned by the melting of snow has been coinciding with the summer monsoon season and any intensification of the monsoon and/or increase in melting is found to be contributing to extreme flooding disasters particularly in the Himalayan catchments (Kameyama et al., 2008).. The consequences of these disasters have been high level exposure to hunger and susceptibility to disease and loss of income and livelihoods (Kameyama et al., 2008; IFAD, 2009). High prevalence of health-related epidemics such as malaria, dengue, and other vector-borne diseases has been experienced after the occurrence of these disasters (Kameyama et al., 2008; IFAD, 2009).

Future expected effects of climate change in Asia has been around sectors such as water resources, agriculture and food security, ecosystems and biodiversity, human health and coastal zones (IFAD, 2009). Climate change is expected to exacerbate many of environmental and developmental problems (Kameyama et al., 2008; IFAD, 2009). For instance, in Central and South Asia, crop yields are predicted to fall by up to 30% in the near future, thus creating very high levels of risk to hunger in several countries (IFAD, 2009; Muralia & Afifib, 2014). Extreme heat is expected to cause disappearance of many glaciers causing serious impacts on the populations relying on the 7 main rivers in Asia which are fed by melt water from the Himalayas, thus exposing more than one

billion Asian people to water shortage leading to drought and land degradation by the 2050 (Kameyama et al., 2008; IFAD, 2009). Furthermore, an increase in the frequency and duration of severe heat waves and humid conditions during the summer is likely to increase the risk of mortality and morbidity, principally in the old and urban poor populations of temperate and tropical Asia; moreover, high temperatures and poor urban air quality, such as in Chongqing, China and in Jakarta, Indonesia, could contribute to widespread heat stress and smog induced illnesses in urban populations (Muralia & Afifib, 2014). Concerning fisheries, sea level rise and changes in sea water temperature, salinity, wind speed and direction, strength of upwelling, mixing layer thickness and predator response to climate change have the potential to substantially alter fish breeding habitats and food supply for fish and ultimately the abundance of fish populations in Asian waters with associated effects on coastal economies (Cruz, Harasawa, Lal, Wu, Anokhin, Punsalmaa, Honda, Jafari, Li, & Huu Ninh, 2007). All the expected misfortunes have forced most of Asian countries to take the fight against climate change very seriously (Kameyama et al., 2008; IFAD, 2009). Besides being exposed to a variety of climate hazards, many countries in Asia are found to be doing their best to adhere to the international call for the adoption of measures to deal with the effects of climate change (IFAD, 2009).

Like many developing countries around the globe, Asian countries are making strides to fight the battle of climate change (Cruz et al., 2007). However, the levels of adaptive capacity are varying between countries depending on social structure, culture, economic capacity, geography and level of environmental degradation (IFAD, 2009).

There has been an increase of capacity to provide for successful early warning systems of extreme weather events in Bangladesh and the Philippines (Muralia & Afifib, 2014). More still needs to be done in terms of capacity to improve resource bases, alleviate inequalities in income, strengthening weak institutions and improve technology (UNFCCC, 2007).). In India a noticeable highlighted is made in its conservation strategy that there is need to develop coping mechanism, especially for its coastal areas (UNFCCC, 2007). In that sense, many CDM projects have been initiated, and substantial research is underway on emissions reduction through the development of energy from sea waves, biomass, or sustainable transport (UNFCCC, 2007). However the Indonesia's national climate strategy has set out more priority issues of the issue of adaptation rather than mitigation (Cruz et al., 2007). Whereas Bangladesh has called for a more intensified regional and global climate coordination with efforts ranging from close diplomacy, projects and financing from countries existing beyond the borders of Asia (UNFCCC, 2006).

3.4.3. South America

South America is comprised of 14 countries which include among others Brazil, Colombia, Argentina and Chile (Seo & Mendelsohn, 2008). In this part of the world, the concerns about climate change have been on the damages it is causing on biological diversity and ecosystems (UNFCCC, 2007; Seo & Mendelsohn, 2008). Climate change is threatening to destroy a wide range of ecosystem properties and species in this region (Aerts, et al., 2004; UNFCCC, 2007). For instance, the Amazon Basin is a home

to about 40% of the world's remaining tropical forest and contains one of the Earth's richest assortments of biodiversity; thousands of species of plants, insect, fish, bird and mammal, thus vulnerable to effects of climate change (Seo & Mendelsohn, 2008). However, just like Africa and Asia, many of the developing countries in South America are found to be vulnerable to climate induced hazards which destroys community's livelihoods and socio-economic infrastructures (UNFCCC, 2007). In this region, small household farms are particularly vulnerable to heatwaves, drought and even foods which does not only destroy their crops but also lead to fatalities (Aerts, et al., 2004). For example, in recent years the continuous experiences of torrential rains and resulting floods, including those associated with tropical cyclones, have resulted in tens of thousands of deaths and severe economic losses and social disruption in the region, and the more noticeable disaster was the 1998 hurricane Mitch which caused more than 10,000 deaths and severe damage to infrastructure, with communities from Honduras and Nicaragua worst affected (Seo & Mendelsohn, 2008). The North eastern Brazil has been particularly affected by drought which hindered crop production processes and killed dozens of livestock (Seo & Mendelsohn, 2008).

Although commercial agriculture and agro-industry businesses are well developed in most parts of this region, there are many places in the continent that still rely on small household farming systems and such farms are more vulnerable to climate change that the larger ones (Seo & Mendelsohn, 2008). Small household farms are more vulnerable to extreme heat while large farms are vulnerable to losses emanating from flooding (UNFCCC, 2007). It is estimated that by the year 2050, almost 50% of agricultural lands

will be subjected to desertification and salinization in most of the areas in the region; thus exposing the majority of population to high levels of food insecurity (Seo & Mendelsohn, 2008). Furthermore, it is predicted that both rain-fed and irrigated farms in arid and semi-arid areas in of the region will affected by receiving limited rain under climate change leading to more degradation of agricultural land (UNFCCC, 2007; Seo & Mendelsohn, 2008). Except for mid-latitude areas, where chemical fertilization effects may balance out the negative effects of climate change, agricultural yields are expected to decrease throughout South America by the end of the current century (UNFCCC, 2007). In other cases, increase in forest fires due to warmer, drier climate and increased deforestation and forest fragmentation will likely heighten the vulnerability of the population to the health impacts of biomass burning smoke, the effects of which have already been observed in some parts of Brazil (UNFCCC, 2007).

Other future predictions include that of an extreme decrease in annual precipitation in most of Central America and in the southern Andes, although large local variability in mountainous areas (UNFCCC, 2007). Increase in winter and summer precipitation in both Tierra del Fuego and south-eastern South America will lead to intense rainfall events causing landslides and severe floods which will destroy crops and other rural livelihoods (Seo & Mendelsohn, 2008). The Andean glaciers disappearance will also likely cause serious effects on people's lives, water supply as well as for hydro-energy, livelihoods and on the ecosystem as a whole in areas such as Bolivia, Chile, Ecuador and Peru, along the Andean Cordillera. Furthermore, low-lying coasts in several countries such as Argentina, Belize, and Colombia will be most vulnerable to extreme

weather events such as rain, windstorms and hurricanes with their associated storm surges and sea level rise (Seo & Mendelsohn, 2008).

With all the inevitable future effects of climate change in South America, many countries are trying to improve measures to deal with the consequences of climate driven hazards (Seo & Mendelsohn, 2008). For instance, Brazil has established inter-ministerial coordination for sustainable development and climate change aimed at taking required measures to deal with the already existing effects of climate change such as drought and tropical cyclones (Seo & Mendelsohn, 2008). Furthermore, Brazil climate change mitigation measures have been through intensification of a host of shared renewable energy ranging from solar systems and wind power (Seo & Mendelsohn, 2008). Also, the social indicators have improved in recent decades in large parts of South America including life expectancy, adult literacy and freshwater access (UNFCCC, 2007). However, the lack of modern observation equipment and climate monitoring has hindered the quality of weather forecasts lowering public trust in climate records and applied meteorological services (UNFCCC, 2007). This occurrence has had a negative impact on the quality of the early warning and alert advisory services compared to developed countries in continents such as Australia (UNFCCC, 2007).

3.4.4. Australia

Australasia is the smallest of the seven traditional continents in the globe, comprised of only four countries (Collins, 2000). In this region, the uncertainty surrounding the

specific impacts which climate change will have on the lives of the people and their livelihoods has forced a drastic rethink of traditional risk management approaches to climate policy, especially in the agriculture sector (Hughes, 2003). Historically, the focal point of climate policy in Australian agriculture has been drought. In policy development since the early 1990s, drought has been considered a natural characteristic of Australia's variable and changing climate (Collins, 2000; Hughes, 2003; Nelson, Kokic, Crimp, Meinke & Howden, 2010). The extreme episodes of drought are reinforced by high temperature rise which are consistent with global trends in recent years (Hughes, 2003). Consequently, most of this rise occurred after 1950, with 1998 being the warmest year, and the 1990s and 1980s being the second warmest decade, respectively (Collins, 2000). For instance, the 2002 drought in the northern part of the Australasia was caused by extreme heat waves which were experienced in winter and spring of that year (Hughes, 2003). However, the extreme temperature rise has also contributed to extreme occurrences of flooding activities in some of the areas in Australia (Hughes, 2003).

In the northern, eastern and southern parts of Australasia there has been a significant change in rainfall patterns (UNFCCC, 2007). Higher rainfall in this area has been associated with an increase in the number of rain days and heavy rainfall events which have consequently caused floods (UNFCCC, 2007). On average, the number of wet days has increased by approximately 10% despite the significant 10% decline in south-west, although this figure is rising towards 20% currently (Collins, 2000). Future changes in temperature and rainfall are predicted to have significant impacts on most

vegetation, rural livelihoods and agriculture as a whole (UNFCCC, 2006). For instance, it is estimated that by the year 2030, annual average temperatures will increase to be between 0.4-2.00C higher over most of Australia, with slightly less warming only experienced in some of the coastal areas and the potential for greater warming in the north-west (UNFCCC, 2007). This forecast has sparked a need for governments in Australasia to devise appropriate measures to deal with the effects of climate change (Nelson et al., 2010).

Some of the noticeable measures to deal with the effects of climate change in Australia have been a huge investment in climate change related research and extension since the year 1980 (Hughes, 2003). The research focus has been on how the seasonal climate forecasting can be used to manage the production risks associated with climate variability within existing farming systems (Meinke and Stone, 2005). Given high levels of vulnerability and low adaptive capacity by farmers in the past, the goal of climate change research and Australian agricultural policy has ostensibly been to enhance the capability of farmers and rural communities to self-manage climate risk (UNFCCC, 2007). Moreover, as has been the case internationally, policies relating to climate variability and change in Australian agriculture have tended to adopt approaches to risk management that focus on selected risks in existing systems that can be quantified and predicted (Hughes, 2003). Furthermore, the establishment of Australia's National Agriculture & Climate Change Action Plan provide for a need for more innovative and holistic approaches to the understanding the vulnerability of Australian rural communities to climate variability and change (UNFCCC, 2007). This plan identifies four

areas for transformative science and policy as follows; the need for adaptation strategies to build resilience into agricultural systems; strong mitigation strategies to reduce greenhouse gas emissions; extensive research and development to enhance the agricultural sector's capacity to respond to climate change; and accelerated awareness and communication to inform decision-making by primary producers and rural communities (Nelson et al., 2010). All these aspects are geared for successful management of climate risk in order to have a definitive characteristic of food production and security excellence in Australasia.

3.4.5. North America

Comprising most of Canada and the contiguous United States, North America is large and diverse in terms of geological, ecological, climatic, and socio-economic structures (Ohring, 2014). Thus, the characteristics of the sub-regions and sectors of North America suggest that neither the impacts of climate change nor the response options will be uniform (Watson, Zinyowera, & Moss, 1998; Stewart, Stewart et al., 2004; Ohring, 2014). In terms of relative contributions to emissions, North America is the worse emitter of greenhouse gases due to its high dominants of industries particularly in the United State (US) (Stewart et al., 2004; Ohring, 2014). However, in this region climate change is only one of many factors that are found to be having serious effect on the overall condition of the ecosystem (Stewart et al., 2004). For example, projected population changes in North America and associated changes in land use and air and water quality will continue to put pressure on natural ecosystems (Stewart et al., 2004).

In terms of temperatures, North American annual trends have been positively increasing and statistically different in the last century in Canada, US and Mexico (Ohring, 2014). For example, in the US, the trends for the three time periods are 0.07, 0.11, and 0.26^0C per decade (Stewart et al., 2004). On the other hand, seasonal and annual precipitation trends are mixed and vary geographically and over different time periods (Ohring, 2014). The most robust trend is a general increase in precipitation in eastern portions of North America over the past full century (Ohring, 2014). For instance, precipitation intensity has been increasing in eastern North America, less so in the northwest US, and very little in the US Southwest (Stewart et al., 2004). The frequency of occurrence of heavy precipitation is increasing for event durations from 1 to 20 days, and return intervals for heavy precipitation are decreasing (Stewart et al., 2004).

In terms of snow cover there has been a tremendous shift in timing towards its contribution to stream flows (Stewart et al., 2004). In this area the river and stream flow is not only the function of latitude, but is also strongly dependent on the local climatic and physiographic setting of each watershed (Ohring, 2014). In particular, the spring snowmelt is the most important contributor of many rivers in western North America (Ohring, 2014). In other words the trends in stream-flow timing, as well as their inter-annual and long-term variability, have been most strongly connected with spring air temperature variations, in the sense that warmer temperatures have led to advances in snowmelt timing (Stewart et al., 2004). Furthermore, since the late 1940s a shift in the timing of snowmelt runoff towards earlier in the water year which is October and September has been observed in many rivers of western North America (Ohring, 2014).

In this sense, water quantity and quality will be directly affected by climate change (Ohring, 2014). Available water supplies also will be affected by changes in demand from multiple sectors competing for water resources; thus, changes in the hydrological cycle will cause a shift in ecosystems which will, in turn, affect human health (e.g., by altering the geographic distribution of infectious diseases) and biological diversity (Ohring, 2014). In the agricultural sector, increases in temperature lead to a rise in evapotranspiration which, unless offset by large increases in precipitation or decreases in plant water use, will results in declines in runoff, lake levels, and groundwater recharge and levels (UNFCCC, 2007; Ohring, 2014). Furthermore, crop losses due to weeds, insects, and diseases are likely to increase and may provide additional challenges for agricultural sector adaptation to climate change (Stewart et al., 2004; Ohring, 2014).

Climate change mitigation and adaptation action plans are developing at a rapid pace, being driven by both local initiatives and emerging alliances and support organizations that cut across multiple jurisdictions (Stewart et al., 2004). Virtually all sectors within North America are vulnerable to climate change to some degree. However, unlike most of developing countries in Africa, Asia and North America, the technological capability to adapt to climate change is readily available, for the most part (Stewart et al., 2004). If appropriate adaptation strategies are identified and implemented in a timely fashion, the overall vulnerability of the region may be reduced (UNFCCC, 2007). However, uncertainties exist about the feasibility of implementation and efficacy of technological adaptation (UNFCCC, 2007). A number of infrastructure sector specific entities exist

that promote coordination for climate change such as the Water Utility Climate Alliance and the research programs of the Water Environment Research Foundation (UNFCCC, 2007). The federal U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) maintain locally based climate action plan (CAP) databases and encourage local initiatives (UNFCCC, 2007). However, the major players on this regard is different local government as they are working close to constituencies and has the ability to influence behaviors in the choice of energy consumption and transportation strategies, and has overall control over the daily routines that involve the use of energy, transportation, and other sources of GHG emissions (Stewart et al., 2004; UNFCCC, 2007; Ohring, 2014).

3.4.6. Europe

Europe is referenced as one of the continents attributed to directly excessive gas emissions, which are believed to cause climate change (UNFCCC, 2006; UNFCCC, 2007). Its industrial development activities produce a lot of pollution which is believed to be altering the composition of the global atmosphere (UNFCCC, 2007). There has been diverse kind of climate change related activities in Europe but with minimal effect compared to the some of the developing countries in other continents (UNFCCC, 2007). For instance, while the area under arable cultivation in most of Western Europe has decreased over the past 40 years, crop yields have increased almost continuously in these areas (UNFCCC, 2007; Miraglia, Marvin, Kleter, Battilani, Brera, Coni, Cubadda, Croci, De Santis, Dekkers, Filippi, Hutjes, Noordam, Pisante, Piva, Prandini, Toti, van

den Born & Vespermann, 2009). This trend has persisted into the 21st century, although crop-yield variability slightly decreased as a consequence of several extreme meteorological events in short succession such as a late frost in 2003 followed by a severe drought which reduced cereal yields over most of Europe and a drought in 2005 which severely affected western Europe (Iberian Peninsula), and an early drought in 2006 which was followed by extreme rains during the summer, resulting in lower cereal production, especially in eastern Europe (UNFCCC, 2006). Other social effects of climate change in Europe include increase in economic losses due to flooding in river basins and coasts driven by increased urbanization, rising of sea levels, coastal erosion and Peak River discharges (UNFCCC, 2007). Also, economic loses has been experienced due to extreme heat events which have an effect on health and wellbeing of the people, labour productivity, crop production, air quality and increased risk of wildfires in areas such as southern Europe and Russian boreal region (Miraglia et al., 2009). Furthermore, in the most parts of southern Europe, there has been an increase in water restriction and significant reduction in water availability from river abstraction and from ground water resource, combined with increased water demand for irrigation, energy, industries and domestic use (UNFCCC, 2006; UNFCCC, 2007). High rates of change were recorded in areas such as central and southern Spain, central Italy, along the Atlantic shores, and in the British Isles, Denmark and the central part of Europe (UNFCCC, 2006; UNFCCC, 2007).

In terms of future climate change predictions, most of European countries will encounter rather different effects and consequently the impact on agriculture and food safety will

vary in different geographical regions (UNFCCC, 2007). These effects particularly on agriculture will cause variations in the seasons, alterations in arable land and crop yields, changes in soil quality (UNFCCC, 2006; UNFCCC, 2007; Miraglia et al., 2009). For instance, an increase of losses of soil mineral, variation in their bioavailability and alteration in soil microorganism ecosystem will be experienced (Miraglia et al., 2009). Changes are also likely to occur both in number and types of plant pests, as well as in the dissemination of vectors, such as biting insects, and in zoonotic diseases affecting domestic animals and human consumers of plant and animal products (UNFCCC, 2006; UNFCCC, 2007; Miraglia et al., 2009). Other aspects of the impact of climate change on food safety include consequences on the livestock production; certain microalgae in seas and oceans; mycotoxins formed by molds growing on crops; residues of pesticides and persistent contaminants; and pathogenic micro-organisms (Miraglia et al., 2009). In the Southern and South-Eastern areas of Europe such as Portugal, Spain, Southern France, Italy, Slovenia, Greece, Malta, Cyprus, Bulgaria, and Southern Romania an annual mean temperature with an increase in the order of 4-50C is projected (Miraglia et al., 2009). This increase will ultimately decreased agricultural yields in the range of 10-30% in many regions of the South), cause drought, heat waves, soil and ecosystem degradation, and eventually desertification in many areas (UNFCCC, 2007; Miraglia et al., 2009). Furthermore, in areas where rainfall does not limit crop growth, these conditions will allow for earlier sowing dates and enhanced crop growth and yield; however, in areas where reduced rainfall is predicted, the increased requirement for irrigation water will have an overall negative impact in economic and environmental terms (UNFCCC, 2007; Leggett, 2009). Again, in most of areas in Southern Europe

where agricultural demand of water is greatest increased water shortages are expected to increase competition for water between sectors such as tourism, agriculture and also energy (UNFCCC, 2006; UNFCCC, 2007; Miraglia et al., 2009). Thus, requiring a firm climate change strategy that will guide the continent of appreciate measures to be taken when mitigating and adapting to the effects of climate change (UNFCCC, 2006; UNFCCC, 2007; Miraglia et al., 2009).

Europe, through its Union action plan on climate change, focuses on accelerating emission reductions, while seeking to put adaptation at the heart of all sectoral policies (UNFCCC, 2006). The action plan highlight that as policy attention to climate change intensifies, mitigation and adaptation increasingly need to be pursued in parallel, and where feasible integrated manner (Miraglia et al., 2009). Climate change risks need to be taken into account, or mainstreamed, throughout the private and public sectors (UNFCCC, 2007; Miraglia et al., 2009). European action also needs to take into account the broader international context, in order to ensure that European Union (EU) efforts are effective, efficient, proportionate and affordable, and coordinated with action in other countries and regions (UNFCCC, 2006). Concerning drought and flood for example the EU plan of action has identified and adopted different policies aimed at flood and drought risk management (UNFCCC, 2007; Leggett, 2009). However, the only dilemma on the issue such as water is that even when most of areas in Europe have several adaptation options available to mitigate the risks of water shortage, the increased irrigation process can further burden surface and groundwater resources, thus increasing greenhouse gas emissions and adding to the mitigation challenge (Leggett,

2009). Consequently, most of the climate change response strategies developed by European countries, particularly on water has focused of ways in which water efficient and saving technology can be established (UNFCCC, 2006; Leggett, 2009). On this regard also a comprehensive implementation of best practice and governance instruments in river basin management and integrated water management is required in these areas (UNFCCC, 2007). These efforts should be accompanied by significant flood-projection technologies in order to for see the likely occurrence of this natural disaster in order that mitigation measures can be adopted (UNFCCC, 2007; Leggett, 2009; Miraglia et al., 2009).

3.4.7. Small Island Developing States

Small Island Developing States (SIDS) are low-lying coastal countries which are comprised of small but growing populations, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade, and fragile environments (Leggett, 2009; Urquhart, 2014). The small island developing States comprise 51 States and Territories spread over the Pacific, Indian and Atlantic Oceans and Caribbean Sea, and are highly vulnerable to the effects of climate change and already feeling its impacts (Urquhart, 2014). The fragile environment and geographical location of these state has rendered the vulnerable to many of climate change induced hazards to the highest level (Aerts et al., 2004; UNFCCC, 2007; Leggett, 2009; Urquhart, 2014). Moreover, the vulnerability is influenced by large ocean atmosphere interactions such as trade winds, El Niño and the

monsoons. Issues such as tropical storms and cyclones have cause storm surges, coral bleaching, inundation of land, and coastal and soil erosion with resulting high-cost damages to socio-economic and cultural infrastructure (Leggett, 2009; Urquhart, 2014). For instance, the World Bank reported in 2006 that the economic loss of the cyclones experienced in the Pacific Islands between 1950 and 2005 has been at a cost of about $75.7 (Urquhart, 2014). Furthermore, the 2004 hurricane season alone caused damages estimated at $2.2 billion in four countries of the Caribbean region including the Bahamas, Grenada, Jamaica and the Dominican Republic (UNFCCC, 2007). With the arable land, water resources and biodiversity already under pressure from sea level rise, increases in population and the unsustainable use of available natural resources has added to the problems (Leggett, 2009; Urquhart, 2014). Also the concentration of large settlements with its associated economic and social activities at or near the coast has rendered Small Island more vulnerability (Urquhart, 2014). The fragile environment and limitation in terms of socio-economic progress has further condemned the Small Island to future hectic climate change effects (Leggett, 2009; Urquhart, 2014)

The relative magnitude of socio-economic losses due to climate change is likely to differ among islands (UNFCCC, 2006). The future projected effects of climate change cross all sectors of the socio-cultural and economic context of Island States (UNFCCC, 2006; UNFCCC, 2006). Whether located in the tropics or higher latitudes are especially expected to face diverse effects of climate change extreme events in the future (UNFCCC, 2006). There is a predicted decrease in rainfall in the Caribbean in the vicinity of the Greater Antilles; however, with an increase in annual rainfall in the

equatorial Pacific and in the northern Indian Ocean, in the Seychelles and the Maldives (UNFCCC, 2006). It is predicted that water supply will decrease because of the high demand and reduced rainfall (UNFCCC, 2006). It is estimated that there will be an approximately 10% reduction in average rainfall by the year 2050, which could lead to a 20% in the size of the freshwater lens on the Tarawa Atoll, Kiribati (Nurse & Sem, 2001). Freshwater supplies will also be threatened by saltwater intrusion due to storm surge and sea level rise for instance (Mimura, Nurse, McLean, Agard, Briguglio, Lefale, Payet & Sem, 2007). The sea-level rice will also threaten prime agricultural land which is located on the coastal plains (Nurse & Sem, 2001; UNFCCC, 2007). Furthermore, the coastlines will almost certainly suffer from accelerated coastal erosion as well as inundation of settlements and arable land with associated social and economic consequences (UNFCCC, 2007). For example, in Grenada, a 50cm rise in sea level could lead to serious inundation with 60% of beaches in some areas being lost (UNFCCC, 2007). A one-meter rise in sea level is expected to cost Jamaica $462 million, 19% of its GDP (Jamaica 2000); while for the Maldives a one-meter rise in sea level would mean the complete disappearance of the nation (Ministry of Home Affairs, Housing and Environment (MHAHE), 2001). Increase in sea surface temperatures and acidification of the oceans will entail a loss of mangrove forests and coral reefs and reduced fish stocks throughout this region (UNFCCC, 2007). For example, it is projected that 3% of Cuba's mangrove forests may be lost with a one meter rise in sea level (UNFCCC, 2007). For the same rise in sea level a complete collapse of the Port mangrove wetland in Jamaica is predicted, since this system has shown little capacity to migrate over the last 300 years (Nurse & Sem, 2001). Unfortunately, there are no

simple solutions to tackle the future predicted challenges faced by the Island states (Nurse & Sem, 2001; UNFCCC, 2006; UNFCCC, 2007).

Many SIDS have severe limitations in terms of human capacity and financial resources, thus making adaptation to climate change difficult (Nurse & Sem, 2001; UNFCCC, 2007). The limitation on adaptation on a high island such as Viti Levu in Fiji, will lead to a damage that could range from $23-52 million by the year 2050 whereas in a low island such as Tarawa, Kiribati, the annual average cost of damages could be estimated to a cost of about $8-16 million (World Bank, 2000). However efforts to address the limitation to adaptation have been through the establishment of Alliance of Small Island States (AOSIS) (UNFCCC, 2007). AOSIS act as voice for the SIDS within the United UN system by calling for action among the international community on the importance of climate change and the need to confront the adverse impacts at the global, national, and sub-national levels (Nurse & Sem, 2001; UNFCCC, 2007). AOSIS is working with partners to focus urgent attention on climate change through the UNFCCC process, in accordance with the Bali Road Map established at the 13th session of the Conference of Parties (COP-13) in Bali, Indonesia, in December 2007 (Nurse & Sem, 2001; UNFCCC, 2007). Some of the proposed future adaptation measures to climate change at the SIDS include integrate rainwater harvesting systems for agriculture and domestic use, thorough assessment of the interaction of climate and other trends and projections demographic, economic and environmental for long range planning and piloting new livelihood strategies based on anticipated new conditions amongst others (Nurse & Sem, 2001; UNFCCC, 2007).

3.5. Global Measures for Climate Change Mitigation and Adaptation

The call for intensification of climate change mitigation efforts is found to be the most difficult to pursue both in developed and developing countries (World Bank, 2000). The reason for this challenge is that different measures aimed at cutting emissions are believed to compromise strides towards achieving economic growth which is much needed to achieve socio-economic development in both first and third world countries (Nurse & Sem, 2001; UNFCCC, 2007). Consequently, mitigation efforts in different parts of the world have remained relatively limited (UNFCCC, 2006). The principal objective of mitigation which is to reduce the levels of greenhouse gases in the atmosphere has been some of the biggest challenge in the climate change discourse (UNFCCC, 2007). Many countries including those in the developed world are found to be reluctant to adjust their practices, processes and structures and to take climate mitigation processes into account, because of the economic compromise which is attached to such an adjustment (Nurse & Sem, 2001; UNFCCC, 2007). Even though prospects are suggesting that renewable electricity generation, for example can have a clear positive effects on local environmental pollution, economic development and employment, while also reducing Green House Gas (GHG) emissions, the shift to reduce greenhouse gas emissions through diversification to different energy sources such as wind, solar, hydropower and geothermal energy is proving to be the most difficult process for many countries to willingly undertake largely due to processes of energy diversification (UNFCCC, 2007). However, many countries in different regions have intensified their work towards climate change adaptation (Nurse & Sem, 2001). Adaptation experiences are increasing across the regions and are becoming embedded in some planning

processes, with more limited implementation of responses (Nurse & Sem, 2001; UNFCCC, 2006; UNFCCC, 2007).

By strengthen governance, reducing non-climate stressors, integrated land and water management, diversifying livelihoods, social protection, behavioral, technological and infrastructural responses and integration of local/traditional and scientific knowledge, countries are trying to provide a firm base to tackle climate change related disasters (Urquhart, 2014). The success to this adaptation process lie on identifying and exploiting synergy, as well as seek to balance trade-offs, among the multiple objectives of sustainable development, disaster risk reduction and adaptation policies (UNFCCC, 2007). The current perception is that climate change activities are not yet prominently featuring well in the environmental and policy agenda of many of developing countries even though they are the most vulnerable to the effects of climate change than any other (UNFCCC, 2007). Many developing countries are said to still regard climate concerns as no more than potential barriers to their ability to reduce poverty and increase income levels (UNFCCC, 2006; UNFCCC, 2007). Most developing countries seem to be ignoring the fact that the future effects of climate change will be severe if they do no formulate proper adaptation methods (UNFCCC, 2006; UN, 2007). For instance, it is predicted that climate-related decreases in food security and increased malnutrition are rated as high risks in Africa, Asia, Central and South America under current levels of adaptation, should global mean temperature increase by 4°C (UNFCCC, 2007). Furthermore, it is estimated that billions of people particularly those found in developing countries face a shortage of water, food and greater risks to health

threats as a result of climate change in the next decade (UNFCCC, 2006). Such a situation will have a devastating effect to the quest towards achieving the goals of sustainable development and also the United Nations Millennium Development Goals (UN, 2007). In these countries, particularly those which are largely dependent on agricultural activities and which are already facing climate change challenges, communities have given adaptation action a high or even urgent priority (UNFCCC, 2006). There are many options and opportunities to adapt at a national level, ranging from technological options such as increased sea defenses or flood-proof houses on stilts, to behavior change at the individual level, such as reducing water use in times of drought and using insecticide-sprayed mosquito net (World Bank, 2000). Furthermore, strategies include early warning systems for extreme events; better water management, improved risk management; various insurance options and biodiversity conservation are the most useful measures to consider for any country (World Bank, 2000; UNFCCC, 2006; UNFCCC, 2007).

3.6. Conclusion

This chapter has argued that the observed human impacts and effects of climate change vary within and across regions, linked to differences in vulnerability and exposure and the extent to which a country can implement adaptation and mitigation measures. Further, it showed that heightened vulnerability to climate change is also linked to multidimensional inequalities often produced by uneven development processes. Thus, the links between climate and poverty alleviation are obvious. Climate change effects dominate the poorest people in developing countries and have seriously

hampered the realization of long-term development goals. The most affected sectors of the society include, agriculture, water resources, human health, terrestrial ecosystems and biodiversity and coastal zones. The aggregate effects are expected to become increasingly adverse, with people living in dry regions or along low-lying coasts, and people with low incomes, expected to be especially vulnerable (UNFCCC, 2006 Questions that one could ask is: what would the world look like if the commitments to food security for all, so often articulated at international meetings, were real? How would it be to live in a world where every person has access to sufficient food to sustain a healthy and productive life, where malnutrition is absent, and where food originates from efficient, effective, and low-cost systems that are compatible with sustainable use of natural resources? The answers to these questions reside in the commitments that each country on the planet earth should make in order to reduce and alleviate the effects of climate change on food production processes currently and in the future (UNFCCC, 2006). Countries such as South Africa should formulate realistic strategies that will not only mitigate and adapt to the effects of climate change but be able to do so without compromising the economic development efforts which are aligned to the priorities of the millennium development goals. Thus, the next chapter examines South Africa's experiences and responses to the effects of climate change on rural food production.

CHAPTER 4

CLIMATE CHANGE AND FOOD PRODUCTION IN SOUTH AFRICA, LIMPOPO PROVINCE AND MAKHADO LOCAL MUNICIPALITY: EXPERIENCES, POLICIES AND INTERVENTIONS

4.1. Introduction

South African households too have been vulnerable to the effects of climate change. Already, a large proportion of the population in South Africa already live in impoverished circumstances, where informal settlements are set up in locations that are vulnerable to extreme weather events, and lack of adequate housing structures to offer sufficient protection against rain, wind and cold (Department of Environmental Affairs and Tourism (DEAT), 2004). Furthermore, the experiences of low and variable rainfall particularly in rural areas have caused disproportionate challenges in terms of access to water. In these areas, most of the surface water resources are already utilized to their full potential; thus, water shortages emanating from climate change has exacerbated the problem of water further (DEAT, 2004). Efforts to provide infrastructure for bulk water supplies are largely provided via a system of large storage dams and inter-basin water transfer schemes and such takes years to develop (StatsSA, 2007). South Africa being a developing country, has been struggling to develop appropriate measures to deal with different aspects of climate change such as adaptation to extreme drought and heat waves. This chapter presents detailed account of experiences of climate change in South Africa, including national efforts to adopt green economic approach, aimed at reducing gas emissions from industries and energy generation.

4.2. National Context: South Africa

South Africa is located on the southernmost tip of the African continent, bordering Namibia, Botswana, Zimbabwe, Mozambique and the kingdom of Lesotho. The country is divided into nine provinces namely Limpopo, Gauteng, North West, Free State, KwaZulu-Natal, Mpumalanga, Northern Cape, Eastern Cape, and also Western Cape (Appendix D: Map 1). The socio-economic conditions and the population numbers of these provinces differ. The provinces are in turn divided into 52 districts: 8 metropolitan and 44 district municipalities. The district municipalities are further subdivided into 226 local municipalities. The metropolitan municipalities, which govern the largest urban agglomerations, perform the functions of both district and local municipalities. To comprehend climate change manifestations and effects in South Africa, it is necessary to examine a variety of contexts, including demographic, economic, social and so on.

4.2.1. Demographic, Economic, Social and Climate Change Issues in South Africa

South Africa is estimated to have about 54 million people of diverse origins, cultures, languages, and religions (StatsSA, 2014). The country is regarded as the fastest growing country in Africa, in terms of population; this scenario is reinforced by a high birth rate and mass migration of foreigners from country as far as Nigeria and Ghana who come to the country looking for better socio-economic conditions and business opportunities.

Table 4.1: Mid-year population estimates by province, 2014

Provinces	Population estimate	% of total population
Eastern Cape	6786900	12.6%
Free State	2786800	5.2%
Gauteng	12914800	23.9%
KwaZulu-Natal	10694400	19.8%
Limpopo	5630500	10.4%
Mpumalanga	4229300	7.8%
North West	3676300	2.2%
Northern Cape	1166700	6.8%
Western Cape	6116300	11.3%
TOTAL	**54002000**	**100%**

Source: Stats SA Census 2011

In economic terms, South Africa has a mixed economy, the second largest in Africa after Nigeria. It also has a relatively high GDP per capita compared to other countries in Sub-Saharan Africa (Stats SA, 2007). However, despite a successful economic growth, South Africa is still burdened by a relatively high rate of poverty and unemployment, and is also ranked in the top 10 countries in the world for income inequality measured by the Gini coefficient (Stats SA, 2011). Again, South Africa has one of the widest gaps between per capita GNP versus its Human Development Index ranking. The most dominant sectors of the economy in South Africa include manufacturing, mining, agriculture, communications, tourism, wholesale and retail trade, finance and business

services. The principal international trading partners of South Africa besides other African countries include Germany, the United States, China, Japan, the United Kingdom and Spain (Stats SA, 2011). The South African agricultural industry only contributes around 10% of formal employment, relatively low compared to other parts of Africa, as well as providing work for casual laborers and contributing around 2.6% of GDP for the nation. Due to the aridity of the land, only 13.5% can be used for crop production, and only 3% is considered high potential land (Stats SA, 2007). Whereas looking at the vast array of food on display in a South African supermarket it may be hard to imagine that food security could be an issue, it is well recorded that there are many households who still struggle to feed themselves in some parts of the country, notably the Eastern Cape where children are still found suffering from malnutrition (Stats SA, 2011).

It is estimated that about 35% of the South African population is vulnerable to food insecurity. That is, a large number of South African households have inadequate or severely inadequate food access (Food and Agriculture Organisation (FAO), 2008). For instance, the General Household Survey (GHS) report indicated in 2008 that food access problems were mostly serious in Free State Province where 33.5% of the households have inadequate food access (Stats SA, 2011). This was followed by households in Kwazulu-Natal with 23%, Eastern Cape with 21,4% and Mpumalanga with 21,5% (Stats SA, 2011). Additionally, Limpopo with 11,9% and Western Cape with 14,5% had the least food security problems in 2008 (Stats SA, 2011). According to the FAO report (2008), high unemployment rate, inadequate social welfare systems and a

high HIV/AIDS infection rate have all contributed to food insecurity in South Africa. Vulnerability to food is most prevalent among black people who live on commercial farms or in the rural parts of the former homelands (Stats SA, 2011). In recent times, in contemporary South Africa income is the principal determinant of household food security (Stats SA, 2011). For monetary income South African rural households mainly depend on sources other than farming, including claims against the state, wage earnings, remittances by kin who live and work elsewhere, and petty trade (Stats SA, 2011).

For agricultural growth and success in South Africa, water availability has always been a big challenge (DEAT, 2004; StatsSA, 2011). Water availability in the arid and semi-arid regions, which cover nearly half of South Africa, is been particularly sensitive to changes in precipitation (DEAT, 2004). The vulnerability of South Africa's climatic system is caused by the fact that it has a generally temperate climate, due in part to being surrounded by the Atlantic and Indian Oceans on three sides, and by its location in the climatically milder southern hemisphere and due to the average elevation rising steadily towards the north (towards the equator) and further inland (Midgley, Spalding-Fecher, Turpie & Winkler, 2002; DEAT, 2004). With climate change becoming more and more of a reality, South Africa is also experiencing a gradual, yet steady, change in climate (DEAT, 2004). Temperatures have risen significantly over the last 60 years, and are predicted to continue this rising trend, with a rise in temperature of 1-2°C expected in coastal regions, and 3-4°C expected in interior regions by 2050 (DEAT, 2004). An increase of 3-4°C in coastal regions is predicted and 6-7°C in interior regions is

predicted by 2100 (DEAT, 2004). Rainfall patterns are also shifting, although this is a little more variable and unpredictable (DEAT, 2004).

Some of the future predictions of climate change in South Africa include that there will be a broad reduction of rainfall in the range of 5% to 10% in the near future (DEAT, 2004). This process will be accompanied by an increasing incidence of both droughts and floods, with prolonged dry spells being followed by intense storms (DEAT, 2004; StatsSA, 2011). The potential effects of this changed climate within 50 years will be on the sectors including human health; maize production; plant biodiversity; water resources; rangelands; and animal taxa (FAO, 2008). Much of the country is arid or semi-arid and the whole country is subjected to droughts and floods (DEAT, 2004; StatsSA, 2011). In other areas, desertification, which is already a problem in South Africa, could be exacerbated by climate change (StatsSA, 2007). About 70% of total grain production in South Africa consists of maize and it is predicted that under a hotter drier climate, maize production will decrease by up to 20%, mostly in the drier western regions (DEAT, 2004). Furthermore, specialty crops grown in specific environmentally favourable areas may also be at risk, since both rainfall and temperature effects may cause significant changes in areas uniquely suitable for such specialised production (DEAT, 2004). In other words climate change effects will be felt more in areas where agriculture constitute a large aspects of household food production and local economic development.

While it is argued that some areas in other countries may benefit from raised temperatures, South Africa's agriculture and forestry sectors are very sensitive to the projected aspects of climate change (FAO, 2008). The most dominate agricultural system in South Africa is small-scale and subsistence farming (DEAT, 2004). Small-scale and subsistence farmers are most vulnerable to the effects of issues such as water shortages and droughts, and while larger commercial farmers have better infrastructure, such as boreholes, windmills, pumps and irrigation systems that may help them to cope with water shortages (DEAT, 2004; FAO, 2008). In terms of forestry, the sector also require large demand of water resources and with a shift in rainfall patterns, wetter areas where commercial forestry was traditionally undertaken may not have sufficient water resources available to allocate to this sector (FAO, 2008). Furthermore, with an increase in temperatures and drop in rainfall, the frequency and intensity of wildfires will threaten many vegetation types, from forests to fynbos (DEAT, 2004; FAO, 2008). Many of these effects will have huge implications on food security, employment, exports (fruit, wine), and tourism (DEAT, 2004; FAO, 2008). But it does not end there, in areas where more rain and higher temperatures are predicted, tropical diseases such as malaria may become more prevalent (StatsSA, 2007). However, the most impacting aspect of these changes will be extreme episode of drought.

Drought is the most important natural disaster in southern Africa in economic, social and environmental terms (Buckland, Eele and Mugwara, 2000). It is considered by many to be the most complex and least understood of all natural hazards, affecting more people than any other hazard (FAO, 2008). This is because drought has a primary and

secondary (ripple) effects on a household or national economy. Primary or physical impacts include reduction in agricultural production, hydroelectric power generation, water intensive non-agricultural production (processing), and domestic availability of water, which has health implications. Secondary impacts are those that affect gross domestic product (GDP), e.g. reduction in industrial output may lead to inflation and lay-off of labour, which increases unemployment (StatsSA, 2007). These factors reduce demand, expenditure, savings and GDP. For instance, after 1992 drought in South Africa, it was estimated that 50 000 jobs were lost in the agriculture sector, with a further 20 000 in related sectors, affecting about 250 000 people (FAO, 2008). Although the direct contribution of the agriculture sector to GDP is relatively small (about 5 percent), it still plays an important role in the economy through backward and forward linkages to other sectors (e.g. the purchase of goods such as fertilizers, chemicals and implements as well as the supply of raw materials to industry) (StatsSA, 2007). However, to overcome some of these challenges South Africa has continuously formulated measures and strategies aimed at mitigating and adapting to the issues of climate change.

4.2.2. South Africa's Climate Change Response Strategies and Policy Measures

The South African view of climate change response is that it offers the country not just one specific avenue of opportunity for achieving the sustainable development objectives of the national policies and legislation, but also to develop measure to remedy both environmental, social and economic ills affecting the majority of its citizens (DEAT,

2004). As a developing country, South Africa is not required to reduce its emissions of greenhouse gases. However, knowing that its economy is highly dependent on fossil fuels, the country has taken strides to promote clean development efforts (Kaggwa, Mutanga, Nhamo & Simelane, 2013). In other words South Africa realises that there could be benefits to be derived from adopting a future strategy that is designed to move the economy towards a cleaner development path. Thus the country developed the Climate Change Response Strategy in 2011. The objective of the strategy is to support the policies and principles laid out in the Government White Paper on Integrated Pollution and Waste Management, as well as other national policies including those relating to energy, agriculture and water (Kaggwa et al., 2013). The strategy also promote integration between the programmes of the various government departments involved to maximise the benefits to the country as a whole, while minimising negative impacts (DEAT, 2004). Furthermore, this climate change response actions is perceived to can potentially act as a significant factor in boosting sustainable economic and social development, a national strategy specifically designed to bring this about is clearly in the national interest, supporting the major objectives of the government including poverty alleviation and the creation of jobs (DEAT, 2004; Kaggwa et al., 2013). Thus, even though the national strategy recognizes international realities, including the growing pressure for quantified commitments of some kind by developing countries, including South Africa, it is developed within the context of the present economic realities of the country and the inequitable distribution of global wealth (DEAT, 2004). In other words, the national climate change strategy for South Africa realises the importance of the achievement of national and sustainable development objectives,

whilst simultaneously responding to climate change. For example, there was a significant concern in South Africa about how the implementation of the Kyoto protocol will affect the coal industry and the 61000 workers it employs (Kaggwa et al., 2013). Other policy measures that the country is considering include development of different laws and legislations aimed at balancing the process of climate change response and economic development (DEAT, 2004; Kaggwa et al., 2013).

The overarching legislation are contained within the provisions of the National Environmental Management Act of 1998. For instance, climate change issues are referred too explicitly in the White Paper on Integrated Pollution and Waste Management of 2000, and referenced in the White Paper on a National Water Policy for South Africa, 1997 (DEAT, 2004). The National Water Resource Strategy also clearly stipulates the importance of taking climate change into consideration. Also the Department of Minerals and Energy has developed a white paper on renewable energy and clean energy development, together with an energy efficiency programme, to support diversification towards a less carbon intensive energy economy (DEAT, 2004; Kaggwa et al., 2013). Furthermore, South Africa as a signatory to the UNFCCC, has to fulfil certain obligations which include preparing and periodically update a national inventory of greenhouse gas emissions and sinks; formulated and implemented national and, where appropriate, regional programmes to mitigate climate change and facilitate adequate adaptation to climate change; promoted and cooperated in the development, application and diffusion of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases; and promoted sustainable

management in the conservation and enhancement of sinks and reservoirs of all greenhouse gases (DEAT, 2004). All these efforts have been in line with the current attempts by the country to adopt and move towards clean energy development process (Kaggwa et al., 2013).

It is a well-known fact that South African economy is highly dependent on fossil fuels, thus, the country can be judged to be a significant emitter comparing to other African countries (DEAT, 2004; Kaggwa et al., 2013). The country is regarded as one the world's top 15 most energy intensive economies, with a significant contribution to greenhouse emissions at a continental level (DEAT, 2004; FAO, 2008; Kaggwa et al., 2013). Furthermore, the South African energy supply has always been dominated by coal, accounting for 79% and of supply in 2000 and 2006, respectively (Kaggwa et al., 2013). Since 1994, the country's job creation rate has lagged behind national economic growth; thus, reinforcing the country to intensify its industrial development which on average of 3.5% economic growth, used a large quantity of dirty fuels for energy such as burning coal for electricity (Kaggwa et al., 2013). Deriving from this scenario, it is evident that in the absence of alternative sources of energy, South Africa the adverse effects of using coal for energy generation will continue to cause more damage to the atmosphere and the environment; thus, threatening the quest towards achieving sustainable development and curbing climate change (DEAT, 2004). However, since 2006, the use of renewable energy has gained momentum in South Africa, although its overall contribution to the total energy supply of the country still remains minimal (DEAT, 2004; StatsSA, 2011; Kaggwa et al., 2013). Growing awareness of the threat of

climate change, rising prices for fossil fuels, growing concerns over energy supply security and recent electricity price increases and blackouts have increased an interest on making re-newable energy more and more competitive in South Africa (Kaggwa et al., 2013). For example, the National Development Plan (NDP) outlines interventions that can put the economy on an environmentally friendly path, and its Chapter Five is wholly dedicated to addressing South Africa's agenda for a greener economy transition (DEAT, 2004; StatsSA, 2011; Kaggwa et al., 2013). Approximately 315 000 solar geysers were installed while 200 000 households were connected to the national electricity grid, following the NDP initiative (Kaggwa et al., 2013). Also, the debate about the usage of nuclear power in the country in the year 2014 emanating from speculations that the government was having talks with countries such as Russia on how they can assist with the establishment of infrastructure in the country reflected the ideal intention by the government on green economy (Kaggwa et al., 2013).

The South African view about renewable energy and/or green economy is that it is a path to sustainable development based on its potential to address the interdependence among inclusive economic growth, social protection and natural ecosystems (DEAT, 2004; Kaggwa et al., 2013). The fact that South Africa's economy is still heavily reliant on extractive industries and that it is among the leading countries in terms of gold and platinum production, and mining which consume a lot of energy, this poses a number of challenges in comprehensively transforming the country economy to a green one (DEAT, 2004; StatsSA, 2011). Green economies are defined as economic systems that take into account holistic remedial measures incorporating economic, environmental

(including ecological) and social challenges that stop or reduce economic activities and growth (DEAT, 2004). Central to this process is the desire to improve people's lives by combating climate change, energy insecurity and ecological instability (DEAT, 2004). However, as with any other new policy initiative, the social and economic impact of the transition to a green economy, in both the short and the long term, is not yet fully understood (Kaggwa et al., 2013). Hence, it is important to assess the implications of this transition at a country level using selected indices, given that South Africa has unique developmental challenges and aspirations comparing to other countries which are adopting the green economy approach (DEAT, 2004; Kaggwa et al., 2013). One of the most important strides which the country needs to take into consideration is to include as many stakeholders as possible into the transition process towards clean energy. In other words, both government institutions and the private sector need to be the key pillars in formulating policy instruments that seek to support the transition to a green economy in South Africa (Kaggwa et al., 2013). For instance, government should continue with the national approach used when formulating enabling and supporting policies for the transition to the green economy such as when the 2006 National Treasury Framework for Environmental Fiscal Reform; the 2008 Department of Science and Technology Ten-Year Innovation Plan; the 2009 National Planning Commission Medium-Term Strategic Framework 2009–2014 and later the National Development Plan in 2011; the 2011 Department of Environmental Affairs National Climate Change Response; the 2011 Department of Environmental Affairs National Strategy for Sustainable Development; and the 2012 Department of Trade and Industry Industrial Policy Plan were formulated (DEAT, 2004; Kaggwa et al., 2013). However, all these

policy documents should be linked to support and improve the already formulated and adopted strategies of climate change adaptation in rural South Africa by both small-scale and subsistence farmers (DEAT, 2004; StatsSA, 2011; Kaggwa et al., 2013).

Given the fact that a large number of people are involved in own and small-scale farming activities in rural areas, much needed support should be given to maximize their efforts to cope with climate change (DEAT, 2004; Kaggwa et al., 2013). Locally based solutions are seen as essential for people to improve the conditions that will enable them to become food secure (DEAT, 2004; Kaggwa et al., 2013). Small-scale and subsistence production in rural areas does not only contributes directly to the households' food security as a supply of food, but also it enables households to divert income to meet other requirements (Kaggwa et al., 2013). Adaptation measures and support should include disseminating information on adoption of changes in agricultural management practices, such as a change in planting dates, row spacing, planting density and cultivar choice, and other measures, which would counteract the effects of limited moisture (FA0, 2008). Also, provision of irrigation equipment to supplement low levels of precipitation can be useful; however, become very expensive and less effective giving conditions of increasing aridity (StatsSA, 2011; Kaggwa et al., 2013). Other approaches to water resources management that will facilitate adaptation to a changed climate include an application of flexibility in water use allocations, water demand management and water conservation measures, contingency planning for extreme events such as floods and droughts, communication, optimizing the operation of existing infrastructure and constructing new infrastructure (DEAT, 2004). Also, the issue of land

distribution should be taken as an area vital to address food insecurity in South Africa (FAO, 2008). Addressing the disparity of land distribution can be crucial towards reducing food insecurity in the country. For instance, the fact that out of about 17.1 million hectares of land owned by black farmers, only 2.6 million is suitable for agricultural production; such should be corrected if subsistence and small-scale agriculture was to flourish in South Africa and food security was to be realized (FAO, 2008; Stats SA, 2007). A success resolution to the issue of land will have positive effect on many farmers in provinces such as Limpopo where rural poverty is still high and subsistence and small-scale agricultural practices are still the corner stones for food security among the large number of households (StatsSA, 2011).

4.3. Climate Change in Limpopo Province

Limpopo Province is located in the northern-most part of the country and it shares borders with Zimbabwe, Mozambique and Botswana. The province is divided into 5 Districts Municipalities and 25 Local Municipalities (Appendix D: Map 2). The population of Limpopo consists of several ethnic groups distinguished by culture, language and race. For instance, about 97.3% of the population is Black, 2.4% is White, 0.2% is colored, and 0.1% is Indian/Asian (StatsSA, 2011). Again, it is necessary to outline provincial contexts, such as demographic, economic and so on.

4.3.1. Demographic, Economic and Household Vulnerability Prospects of Climate Change

In terms of demographics, Limpopo Province is estimated to be the home of about 5.4 million people distributed across 5 districts (Appendix D: Map 2) found in the province. The majority of Limpopo Province population is found in rural areas where poverty is still a big challenge. Thus, they are exposed to many climate change related natural hazards.

Table 4.2: Limpopo Province Population by District

District Municipality	**Population**
Capricorn District Municipality	1,261,463
Mopani District Municipality	1,092,507
Sekhukhune District Municipality	1,076,840
Vhembe District Municipality	1,294,722
Waterberg District Municipality	679,336
TOTAL	**5 404 868**

Source, Stats SA

Economy-wise, the province is a typical developing area, exporting primary products and importing manufactured goods and services (StatsSA, 2011). The province has shown great improvements in the economy and in standard of living in recent times (StatsSA, 2007). Most of the economic activities in Limpopo revolve around agriculture, both commercial and small-scale (DEAT, 2004). The subtropical climate enjoyed by

much of the province gives rise to the cultivation of tea, coffee and fruits, especially tropical fruits (DEAT, 2004). Forestry also makes a major contribution to the economy, as do tobacco, sunflower, wheat, cotton, maize, and groundnuts production (DEAT, 2004; StatsSA, 2011). For instance, much of the sunflowers, cotton, maize and peanuts are cultivated in the Bela-Bela and Modimolle areas of Limpopo province, whereas tropical fruit such as bananas, litchis, pineapples, mangoes and pawpaw's as well as a variety of nuts, are grown in the Tzaneen and Louis Trichardt areas (DEAT, 2004; StatsSA, 2011). Furthermore, Tzaneen is also at the centre of extensive citrus, tea and coffee plantations, as well as forestry. With all this high economic reliance on agricultural activities, Limpopo Province is found to be the most vulnerable to aspects of climate change. For instance, drought is a recurring problem in Limpopo Province (DEAT, 2004; StatsSA, 2011).

As a consequence of severe drought, the province has experienced reduced grazing and water for livestock and irrigation which negatively impacted the agricultural sector and hence resulting in limited food access and distribution (Letsoalo, 2013). For example, the occurrence of drought in 2009 was the worst ever in Limpopo Province and it caused a lot of damage (StatsSA, 2011; Maponya & Mpandeli, 2012). During this period, most of dams in the province were only 50% full, compared with 84% in late nineties (StatsSA, 2011). Furthermore, given an estimate of 3 million farmers in South Africa who produce food primarily to meet their family needs, drought has worsened rural poverty in Limpopo Province (Stats SA, 2007). It is also reported that climate change is costing communal farmers hundreds of lost livestock due to ~~a~~ lack of grazing

and water shortages. Such circumstances have resulted into some farmers accusing government of managing crisis instead of implementing preventative measures (Maponya & Mpandeli, 2012). They are also accusing government of not providing them with information on how to manage their livestock amid climate change which is increasing temperatures and causing continuous episodes of heat waves (Maponya & Mpandeli, 2012). It is recorded that there has been a significant increase in temperature over the past 20 years in Limpopo (Maponya & Mpandeli, 2012). Thus, temperature changes have led to changing patterns of precipitation, the spatial and temporal distribution of runoff, soil moisture, and groundwater reserves, as well as (increase) in the frequency of occurrence of droughts and floods (Tshiala, Olwoch, & Engelbrecht, 2011; Maponya & Mpandeli, 2012). Author recorded that, the seasonal trends showed variability in mean temperature increase, of about 0.18°C per decade in winter and 0.09°C per decade in summer from 1960s to around the year 2003 (Gordon, 2005; Revi, 2008; Roberts, 2008). Furthermore, the average temperature trend from 1991 to 2003 was 0.09°C per decade, compared with 0.11°C per decade from 1960 to 1990 (Maponya & Mpandeli, 2012). The agricultural misfortunes faced in the province requires government, particular local municipality to play a biggest role in planning how households should be assisted especially with their food production and security efforts (Tshiala et al., 2011; Maponya & Mpandeli, 2012).

4.3.2. The Role of Local Government on Climate Change

In recent years, climate change has emerged as an important extension of environmental management mandates formulated after 1994 in South Africa, when new local government structures began to emerge in response to the changing policy and legislative policies with specific environmental management mandate and focus (Gordon, 2005; Revi, 2008). Totty (2009) argue that, the management of climate change impacts as an extension of existing risk management should build on existing effective risk and hazard arrangement.

One of important part of facilitating the integration of climate change to the existing risk and hazard assessment is the need to initiate and provide improved natural hazard risk assessment, management and mitigation capacity that respond to major disaster among the municipal officials dealing with environmental management (Gordon, 2005; Revi, 2008; Roberts, 2008). This process may require the redirection of investments and programmes in order to build new alliances between wide ranges of actors not often in engagement (Revi, 2008; Roberts, 2008). Also, IDP process should create advocacy among local politicians and civil servant, consider climate change significance in municipal plans and in decision making and channelling staff and funds in climate change initiatives (Gordon, 2005). In these sense, a successful process of integrating climate change at a municipal level requires the cooperation of both government official and other stakeholders (business, communities and non-profit organisations) (Gordon, 2005; Revi, 2008; Roberts, 2008).

Identifying the roles of government in adapting to climate change is the first step in building a coordinated approach (Gordon, 2005). Gordon (2005) asserts that, government at all its spheres should combine a response required to tackle the impact of climate change. Once the roles of each sphere are broadly agreed, responsibility for specific tasks should be stipulated (Gordon, 2005; Revi, 2008; Roberts, 2008). The capacity, knowledge and experience should inform the responsibility and accountability of a specific sphere (Carmin, Roberts & Anguelovski, 2009). National and Limpopo provincial government may provide guidelines and draft policies to facilitate the process of addressing climate change; however, local government should be on the frontline in dealing with the impact of climate change because they have a critical role to play in ensuring that particular local circumstances are adequately considered in the overall adaptation responses and in involving the local communities directly in efforts to facilitate effective change (Revi, 2008; Roberts, 2008; Carmin et al., 2009). Again, local government structures are strongly positioned to inform other sphere about the community needs by directly communicating with communities and responding appropriately and in a timely manner to local changes (Carmin et al., 2009). Limpopo Municipalities should be capacitated with skills and financial resources to integrate climate change in their continued efforts to facilitate management of risks and hazards to public assert and service delivery (Roberts, 2008). This process should also ensure policies and regulation including local planning and development regulation, incorporate climate change consideration; they should facilitate building resilience and adoptive capacity in the local community, including through providing information about relevant climate change risks; contribute appropriate resources to prepare, prevent, respond and

recover from detrimental climate impacts (Carmin et al., 2009). The other important part for municipalities to consider is working in partnership with communities and Non-Governmental Organisations (NGO's), business and other key stakeholders to manage the risks and impacts associated with climate change (Roberts, 2008; Carmin et al., 2009).

Government at all levels, businesses, households and the communities at large have important, complementary and differentiated roles in adapting to the impacts of climate change (Revi, 2008). However, given that a number of stakeholders have little or no knowledge on climate change issues, the development of a framework linking dialogue, engagement and action would be a useful step (Roberts, 2008; Carmin et al., 2009). For communities and other stakeholder to participate in dealing with climate change impacts, government on its capacity should make them aware of the risks and responsibilities for managing them in order to take steps to understand the magnitude and nature of the specific risks to their assets and activities in order to develop and implement strategies and actions to manage them (Revi, 2008). It is not feasible nor appropriate for government to bear all the cost of adopting to the impacts of climate change, it would also be inefficient and inappropriate for government to make decision on behalf of business and individuals that are better placed to understand and manage their own risks (Revi, 2008; Roberts, 2008). So, it is important for local municipality in Limpopo Province to capacitate communities to deal with climate change appropriately by recognising and empowering them.

4.3.3. Local Communities and Household's Climate Change Adaptation Measures

In the Limpopo Province, which has a large rural population dependent on agriculture, farmers are obligated to adapt to climate changes compared with those in the others provinces (Tshiala et al., 2011). This has been the case where farmers are found to particularly require to diversifying their portfolios, using irrigation, and changing planting dates amid climate change (Roberts, 2008; Carmin et al., 2009). For example, in Sekhukhune District of Limpopo there is evidence that people are developing adaptation strategies to changing patterns of water availability and the ever-prevalent stress of limited finance (Tshiala et al., 2011). For instance some small-scale farmers in in this region have set up traditional food seed banks to help maintain food security and at the same time help curb climate change (Stats SA, 2007). Other forms of adaptation at a local small-scale level include planting different crops, changing crop varieties, changing planting dates, increasing irrigation, diversifying crops, changing the amount of land grazed or under cultivation, and supplementing livestock feed (Stats SA, 2007; Tshiala et al., 2011). Some farmers are also planting traditional crops which are drought resistant and do not require any chemical fertilizers or pesticides (Stats SA, 2007). However, in Limpopo more rural areas farmers are cited to have a number of barriers to adaptation including extreme poverty, lack of access to credit, and lack of savings (Stats SA, 2007; Tshiala et al., 2011). Insecure property rights, lack of markets, lack of information and knowledge of appropriate adaptation measures are also cited as significant barriers to adaptation (Tshiala, Olwoch, & Engelbrecht, 2011; Maponya & Mpandeli, 2012). But for those with greater management and technical skills, they are better able to cope with climate variability and change, and to spread risk by exploiting

strategic complementarities among activities (Stats SA, 2007; Tshiala et al., 2011). Unfortunately for many households practicing subsistence and small-scale farming in rural local municipality such as Makhado, it has been difficult to manage the effects of climate change.

4.4. Locating Makhado Local Municipality in Vhembe District Municipality

Vhembe is one of the 5 districts of Limpopo Province located at the northernmost part of the province bordering with Zimbabwean Beitbridge District in the Matabeleland South. The district municipality consist of all territories that were part of the former Venda Bantustan, however, two large densely populated districts of the former Tsonga homeland of Gazankulu, in particular, Hlanganani and Malamulele are also incorporated into Vhembe, hence the is ethnic diversity in the District. According to Statistics South Africa's census 2011, Vhembe District Municipality host an estimated number of over one million residence which are spread around four local municipalities; namely Thulamela, Mutale, Musina and Makhado (Appendix D: Map 3) which is the area of study for this research.

Table 4.3: Vhembe District Municipality Population Distribution

Local Municipality	**Population**
Makhado Local Municipality	516031
Musina Local Municipality	68359
Mutale Local Municipality	91870
Thulamela Local Municipality	618462
TOTAL	**1294722**

Source: Stats SA Census 2011

4.4.1. Demographic Agricultural, Economic and Poverty Profile of Makhado Local Municipality

The extreme levels of poverty and inequality are said to have been reinforced by economic trends that have impacted harshly on semi-skilled and unskilled workers. This includes the seasonal nature of agricultural, tourism and domestic work. Furthermore, large disparities exist between the different communities with regard to their respective levels of development. Thus, the size of the Municipality has brought about a situation where there are villages that are fairly well developed in contrast with other rural areas, which are developing very slowly (MLM, 2014). Some of the factors causing high levels of poverty include the fact that at present the local economy is unable to provide sufficient employment opportunities to meet the needs of the economically active population. Most of the economic activities and opportunities which can assist the poor are being undermined by lack of connectivity between residential areas and economic

hubs (between towns), poor levels of social cohesion (MLM, 2013). Furthermore, fragmentation of residential development has given rise to the duplication of services, which are costly and inefficient. It appears that water is the scarcest natural resources in the municipality. Thus, most rural villages do not have access to water per household stand. In recent times, increasing population levels and a variety of land uses have placed an increasing demand on water availability and thus impose pressure on water resources and the future need for alternative resources (MLM, 2013; MLM, 2014). Again, most of the areas in-between settlements are utilized for farming purposes resulting in these areas being under constant threat of environmental degradation. The physical development in these areas largely takes place in reaction to new needs that manifest over time. The municipality does not have integrated environmental programmers and as a result communities in the area are ignorant of fundamental environmental principles such as water saving and pollution management. With all this disparities the municipality is at great danger of a socio-economic collapse due to the effects of current and future aspects of climate change. Some of the already experienced climate related hazards in the municipality include veld fires, floods, droughts and extreme heat waves (MLM, 2014). This has had a huge impact on both household and large scale food production activities such as agriculture which is supposed to be the corner stone for household's socio-economic needs and municipal local economic development.

In Makhado, agriculture is one of the most important economic sectors and it is the third largest employer absorbing around 17% of the labour force (MLM, 2013). It is well

recorded that a well-coordinated strategy can lead agriculture to be the main field that can bring about future sustainable development of the Municipality (MLM, 2014). This is because favorable conditions for agricultural development are in place such as fertile land and a suitable climate that can result satisfactory yields (MLM, 2013). Furthermore, the municipality has certain advantages which can be attributed to its location which are its strong commercial agricultural sector, and access to local and African markets via the N1 road connecting to international markets through the Gateway International Airport in Polokwane (MLM, 2014). However, agriculture within the area is diverse in the sense that it is made up of commercial, emerging or small scale and subsistence farming (MLM, 2014). Farming activities includes crop-production, livestock production, agro-processing, forestry, and aquaculture (MLM, 2014). The commercial agriculture sector is well structured, and it is more predominant in areas such as the Levubu valley, the Soutpansberg, Waterpoort, and Makhado town (MLM, 2013). Nevertheless the potential of more intense commercial agriculture has been undermined by lack of infrastructure as well as training and financial support for local aspirant farmers (MLM, 2014). In terms of small-scale and subsistence farming, many areas in the south-east part of the municipality are found to be dominant and greatly corresponding with traditional authority (MLM, 2013). For instance, many small-scale farming activities are found in the various irrigation schemes such as Nesengani, Mphaila, Mandiwana, Mphephu, Madzhatsha, Rabali, Mauluma, Mavhunga, Cape Thorn and Raliphaswa (MLM, 2014). However, for these small-scale emerging farmers, poor physical access to local, regional and international markets has been one of the significant barriers to greater agricultural productivity (MLM, 2014). Cost effective, reliable, timely and fit-for-

purpose transport is often not available (MLM, 2014). A lack of timely transport is one of the reasons that devastating proportions of the harvest are wasted and why accessing markets is so challenging (MLM, 2013). High transport costs are also exacerbated by the high prices of diesel which is also used for tractors and water pumping generators (MLM, 2013). As part of linking emerging farmers with the markets, Vhembe District Municipality has since established the Vhembe Fresh Produce Market which is located in Tshakhuma Village. This market specializes in fresh produce sourcing, grading, packaging, distributing and market linkages, and it is open and accessible to all local farmers (MLM, 2013). However, the issue of land access among small-scale and subsistence farmers have been a big concern in recent times (MLM, 2013; MLM, 2014).

Land within Makhado is comprised of residential land, forests, agricultural land, and industrial land amongst others. For instance, most of the commercial/industrial land is in Makhado town; cultivated land in areas such as Levubu, Waterpoort, Makhado; forestry in Makhado, Elim, Ratombo and subsistence farming in rural areas (MLM, 2013). In tribal areas the dominant form of land tenure is the Permission to Occupy (PTO) (MLM, 2014). Over 49% of land is under private ownership at the municipality and at least 30% of inhabited is owned by government in various forms (MLM, 2013; MLM, 2014). This category includes tribal land, land held by government departments but excluding parastatals who owns 3% of the land within the municipality (MLM, 2013). Government owned land is distributed in large pockets in the north-eastern portion of the Makhado town within the former Venda homeland area, eastern and south-eastern portion of the Municipality within the former Venda and Gazankulu homelands areas; and south-west

of the Makhado town within the former Venda area. Private land is located primarily through the central and western portions of the Municipality with the exception of the Levubu area (MLM, 2013; MLM, 2014). The issue of land claims has been a big thing since its inception in 1998. By the year 2011 about 898 land claims had been settled from a total of 1024 which were initially lodged in the area (MLM, 2013; MLM, 2014). The number of urban claims equals 129 and rural claims are about 748 of which the outstanding claims are 124 (MLM, 2014). This has resulted in normally land under land claim or restitution not to be considered for development immediately, or at least without further consultation with affected communities thus hampering development processes such as crop production in the municipality (MLM, 2013; MLM, 2014).

A range of crops and fruit are produced within the areas of Makhado municipality including macadamia, avocados, mangos, litchis, and bananas (MLM, 2013). Most of large areas are under the production maize, macadamia nuts, avocado, bananas, potatoes and tomatoes (MLM, 2013). Other crops which are produced within Makhado Municipality include groundnuts, beetroot, cauliflower, peppers, chilies, peach, table grapes, and squash (MLM, 2013). The abundance of avocados in the area has provided opportunities in the processing of avocados into domestic oils, puree, medicinal uses, and cosmetics (MLM, 2013; MLM, 2014). Furthermore, about 12% of the total lands in Levubu are has been under banana cultivation which makes the area one of the major banana producers in Limpopo after the Tzaneen area (MLM, 2014). The cultivation of commercial crops and fruits has corresponded with the processes of livestock rearing. In Makhado, animal farming mainly focuses on cattle, goat, sheep, pork, poultry and

game. In terms of poultry farming, most farmers either operates as individuals or in groups, and in some instances cooperatives have been formed so as to facilitate access to finance and support (MLM, 2013). The main reason for poultry farming is to raise the chickens for meat production and eggs. In 2011 there were thirty two broilers facilities in Makhado. Broiler production, especially broiler meat production, was the largest segment of South African agriculture by 24% in 2009 while all animal products in South Africa contribute 48% (MLM, 2013). On the other hand game farming has also been dominant in Makhado Local Municipality. The game farming is predominantly at a commercial level and the game is kept for reasons such as trophy hunting, game meat, taxidermy, and tannery. Some of the animals that are kept by game farmers include Springbok, Kudu, Impala, Nyala, Wildebeest, and Gemsbuck (MLM, 2013; MLM, 2014). However, the game meat production in Makhado is relatively small compared to other meat production (MLM, 2014). All these food production practices including those that are done by poor households are found to be dependent on the environmental and climatic conditions in the municipality.

Over the years climatic condition within Makhado Municipality supported a variety of agricultural activities as the temperature ranged between 18^0C in the mountainous areas to 28^0C in the rest of the area, with an average of 25.5^0C (MLM, 2013). The general average rainfall in Makhado ranges between 450mm to 800mm, with areas north of the Soutpansberg having less rainfall than the lower western foothills and central and eastern high lying areas of the mountain itself (MLM, 2013; MLM, 2014). However, in recent times the weather patterns have been unpredictable and

inconsistent causing variations in food production activities particularly among the poor households in rural villages. The most recognizable river systems include the Sand and Hout, the Luvuvhu, the Little Letaba and Nzhelele. However, most of these and other former main river systems such as Dorinspruit, Sand (upper parts), Hout, Little Letaba, Soeketse, Middle Letaba, Luvuvhu (lower parts), Lutanandwa, Mutshedzi, Tshiluvhadi, Dzindi, Mutshindudi, Mutamba, Nzhelele and Nwanedzi Rivers do not hold water, amid high temperatures and limited rainfall (MLM, 2014). To cope with these misfortunes, the municipality has formulated different agricultural development programs to assist farmers and households to deal with current and future aspects of climate change.

The aim of these programs and projects is to expand production in the commercial and emerging subsistence agricultural sectors, encourage diversification and promote beneficiation of locally produced products (Stats SA, 2007). The municipal position is that both commercial, small-scale and subsistence farming activities have an opportunity to grow even with high dangers of climate change river systems. However, only if required measures are put in place to support and uplift the production process to the higher levels. This can only be done if farmers are assisted with marketing opportunities of their products, costs of maximizing inputs are covered and transport for their goods is subsidized among other things (MLM, 2013; MLM, 2014). Some of the programs that the municipality is engaging on include influencing farmers to diversify into niche markets (MLM, 2014). Greater emphasis is placed on developing new niche products in the agricultural sector, in particular products better suited for water scarcity which is a challenge in the area and the changing climate (MLM, 2013; MLM, 2014). For

instance, the current climatic and environmental conditions give great possibilities for the development of honey-production (MLM, 2013; MLM, 2014). Another niche area project of high value could be the cultivation, harvesting and processing of the Moringa crop. Moringa is a suitable candidate for commercial establishment, as it, despite mostly naturally occurring in the tropics and sub-tropics can tolerate higher temperatures and/or survive light frost and tolerates a wide range of soil and rainfall conditions (MLM, 2013). In Makhado a multi-purpose crop, such as Moringa will benefit rural communities in the sense that large scale plantations will provide substantive real employment opportunities and sustainable income for marginalized communities (MLM, 2014). The Moringa crop can be beneficiated to produce oil for human consumption and bio-fuel; leaf powder for human and animal consumption; press cake and animal fodder; and medicinal products (MLM, 2013; MLM, 2014).

The second most important program to be implemented in Makhado is of development of emerging farmers (MLM, 2013; MLM, 2014). It is important to partner existing agricultural stakeholders including the private sector for the implementation of a comprehensive emerging farmer's development program to improve access to business advice and technical information, skills transfer, infrastructure and market access (MLM, 2013). A lack of training and skills, both for emerging farmers can be a barrier to achieving innovation, value added, and other profitability goals (MLM, 2013). The small scale farmers in Makhado produce a wide range of agricultural products and although high quality products are being produced locally, these products are poorly marketed and therefore often only sold in local markets. Significant challenges still exist in

accessing national and international markets (MLM, 2013). Thus, the municipality should also assist small and medium scale farmers to attend trade fairs and agricultural expo's to market their produce to both local and international markets.

The other program of pragmatic importance in Makhado is of promoting commercial farming activities in rural areas (MLM, 2013). Plenty of cattle farming activities at a small scale occur in the rural areas, but without any profitable markets (MLM, 2013). These farmers use communal land for grazing, and there is a need to formalize and commercialize their activities through the development of a feedlot which could enhance the quality of their livestock. Hence there is a very strong need for a commercial feed mill in Makhado, given the large herd sizes of livestock (sheep, goats, dairy cattle, etc.), and poultry, and the lack of nutritional feed to service this need (MLM, 2013; MLM, 2014). The objective of the commercial feed mill will also be to strengthen the capacity of farmers to increase production of row crops and legumes, develop nutritionally balanced feed rations, and promote the efficient use and increase of animal production inputs (MLM, 2014). Furthermore, because many rural farmers lack access to agricultural inputs such as fertilizers, quality seeds and seedlings, farming equipment's, it is imperative to therefore establish rural agro-support centers which will incorporate all the agricultural inputs in the rural areas in an affordable and reasonable prices for small-scale and subsistence farmers to be able to afford (MLM, 2013; MLM, 2014).

4.5. Conclusion

This chapter has demonstrated that climate change is a truly cross cutting issue which affects the entire economy as well as many specific sectors including energy, transport,

agriculture, forestry, water resources management and provision of water services, and health in South Africa and its province. Even though South Africa is regarded as a self-sufficient in food production at the national level, the recent unprecedented climate induced natural disasters are threating food security status of the country, particularly in rural areas where poverty still persists. Aspects of climate change such as drought and floods have destroyed harvest of many subsistence and small-scale farmers, calling for government to avail serious intervention to cover the loss. That is why when the Minister of Finance was tabling his first main budget, for 2015/16, in the National Assembly, outlined that the South African government planned to acquire 1.2 million hectares of land in the next three years, with R4.7 billion allocated for developing farms through the Fetsa Tlala food security strategy (Department of Finance, 2015). Furthermore, he highlighted that this intervention will target more than 4 million people in South Africa who are engaged in smallholder agriculture in rural area such as those in Makhado Local Municipality, where subsistence agriculture dominates (MLM, 2014). The next chapter examines data collected from 30 villages in the Makhado Local Municipality.

CHAPTER 5

MAKHADO LOCAL MUNICIPALITY SURVEY RESULTS: DATA ANALYSIS AND INTERPRETATION

5.1. Introduction

Makhado Local Municipality is one of the areas in Limpopo Province where a large number of households are still living under extreme conditions of poverty. Issues such as unemployment and at times food insecurity affects a large number of households, particularly those who are found in rural areas where socio-economic conditions are not yet fully transformed. In these areas the practice of substance farming has been for years, a pillar for food security. For instance, historically, production of food crops, vegetables and also fruits kept many households food secured for many years. However, it is revealed during the current study that household food production has been diminishing in rural Makhado Local Municipality. The reason behind the decline of household own food production activities lies on the fact that the climatic, weather and temperature conditions have drastically changed in recent times in such a way that it has affected the successful harvest that communities used to have before when practicing subsistence and small-scale farming.

Climate change induced extreme episodes of drought and heatwaves are the most experienced hazards which are affecting household food production in recent times at the municipality. Furthermore, unprecedented events of precipitation such as hail and thunderstorms which were not experienced constantly before are now causing a lot of

damage to crops and also livestock which some households are still growing. Interestingly, it was uncovered that different rural areas of the municipality have been experiencing different effects of climate change even though they are based in the same region. Some household respondents identified heatwaves as the biggest climate change-related hazard that they are facing whereas to others erratic rainfall has been a major challenge. One other interesting observation has been that because of lack of enough rainfall, better-off households have turned into establishing boreholes to access ground water, and such arrangements have allowed them to continue producing food in their yards. However, poor households who desperately need food self-provisioning for survival are unable to access alternative water sources than rain because of the limitation of financial resources. Given climate change-related misfortunes, many households in rural Makhado Local Municipality are now vulnerable to food insecurity and are failing to diversify to other socio-economic avenues which can afford them a chance to access adequate food.

This chapter analyses the data which was collected in rural Makhado Local Municipality. Data was collected through administrating questionnaires within households, conducting interviews with key informant of which majority were elderly community members in different villages and observation of the land scape, production activities and settlements patterns in the areas. Different themes concerning the effects of climate change on food production in Makhado Local Municipality are analysed. Firstly, an attempt to create an understanding of the local household's perceptions on the systems and processes of climate change will be created. Secondly, different aspects pertaining

Makhado's household food production activities will be analysed, looking particularly at types of production activities, description of the products produced and main challenges faced during production amongst others. The third part of this chapter analyses different aspects of the environmental condition and its conduciveness for food production at the municipality. The last part of this chapter explores the relationship between climate change and food production, focusing on different experiences of climatic and temperature conditions and how such conditions affect food production. It is worth noting that the data collection and analysis for this study embraced a historical dimension in order to trace the manifestations of the factors under investigation and their association through periodization. Thus, the questions asked to the respondents and the analyses presented involve events of climate change and food production pre- and post-1990.

5.2. Rural Makhado Households Perceptions on the Systems and Process of Climate Change

The understanding of what constitutes and determines the bases for the formation of climate change has always been a debatable issue among scholars, practitioners and ordinary people. Climate change sceptics have always maintained that the release of gas emission in the atmosphere has nothing to do with the recent events of climate change, stressing that it is a normal process for climate to change overtime. However, climate change believers have blamed industrialization which contributes significantly to gas emissions to be the cause of climate change. Interestingly, there is a different

sense of understanding which was drawn from different respondents when it comes to questions of what they thought was the cause of the recent episodes of erratic rainfalls, heatwaves, drought, floods and other extreme episodes of natural hazards (climate change) in rural Makhado Local Municipality. The responses to this question range from mythical issues such as that the angry gods and ancestors are punishing people because they are no longer obeying them like before. Also, other views are that people have abandoned performing rituals which were believed to be necessary for inviting rainfall during production seasons.

Bearing in mind that the majority of respondents are in rural areas of Venda and Tsonga decent, where traditional customs, believes and sense of mythological guidance are paramount, understandings of climate change are materially different from the theoretical and scientific standing which has been portrayed in different parts of chapters 2 and 3. It was further understood that this unorthodox understanding of what constitutes climate change in rural Makhado Local Municipality might have in one way or another been influencing the manner in which most households responded to the different effects of climate change. Moreover, it was clearly observable in the analysis that a significant number of households have abandoned their food production activities because of the limited harvest that they have been making in recent years. For example, most households who reared large herd of livestock previously are incrementally left with fewer. This scenario raises a question whether some of the customs, cultural and mythical beliefs and perception that people have in the villages

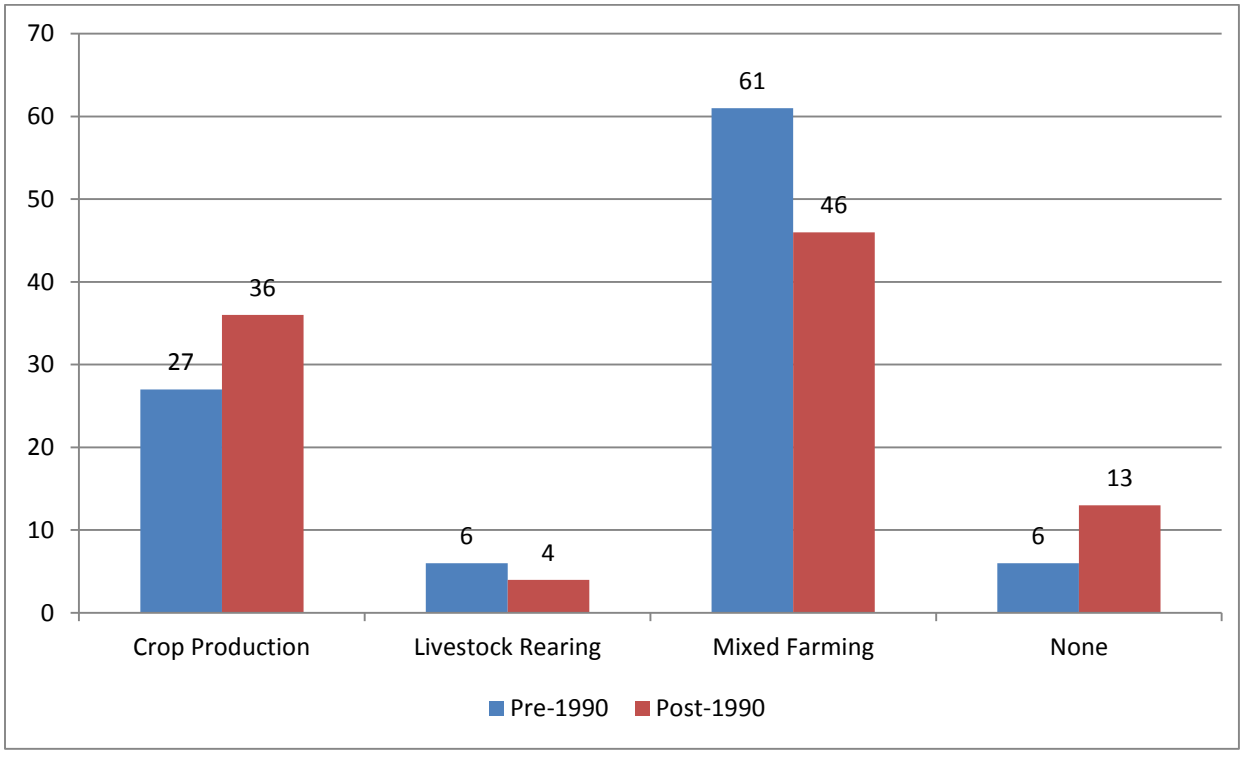
have contributed to the abandonment of food production activities thinking that their gods are too angry to forgive them.

5.3. Types of Household Food Production Activities, Pre- and Post-1990

In the pre-1990 period, the majority (61%) of respondents stated that their households practiced mixed farming activities which integrated both crop production and livestock rearing (figure 5.1). The reason for practicing such activities was that there was limited income earning opportunities for household members to afford buying food. The other reason was that the majority of households had access to fertile land to cultivate and produce enough food to survive and also that there were tracts of land for livestock grazing. A less significant proportion (27%) of household respondents highlighted that they practiced crop production alone whilst only a negligible percentage (6%) focused on livestock rearing. Furthermore, a similarly negligible proportion (6%) of respondents mentioned that their households did not practice food production activities at all in the pre-1990 period. Interestingly, there is a slight change in numbers in the post-1990 era. However, with a noticeable decline, still a relatively significant proportion (46%) of respondents highlighted that their households practiced mixed farming in the post-1990 era. Evidently, there is an increase in the proportion (36%) of the respondents who only practiced crop production and a slight decrease for those who only focused on livestock rearing in the post-1990 period. Whilst negligible, there is increase in proportions (13%) of households who do not practice any form of food production activities during this period. Some of the reasons given by those who have neglected their food production

activities included, among others, the lack of access to fertile land, unsuccessful harvesting due to land degradation and limited rainfall. For those who still tried to practice one or two of the food production activities even with limited success, the reason has been lack of choices to diversity their food production activities, also as a supplementation of social grant income that the household receives, particularly where headed by elderly people. Also, some still practiced food production activities because of the longstanding perception that self-provisioning is always cheaper than purchasing from the market. The analysis above attests to the theoretical grounding presented in chapter 2, which holds that climate change is in the forefront of the negative influences on food production and has caused a significant decline in agricultural production, affecting livelihoods for food security in rural areas (Gregory et al., 2005).

Figure 5.1: The Proportion of Types of Household Food Production Activities, Pre- and Post-1990



The general community circumstances of food production activities as outlined by key informants affirm household respondents' narratives. Majority of key informants alluded to the fact that in rural Makhado Local Municipality most households practiced both crop production and livestock farming in the pre-1990 era. Majority of households in different villages were subsistence farmers who were mostly dependent on food self-provisioning for food security purpose. In these areas, crop production used to be conducted during different seasons in order to cater for production of crops such as maize, butternuts, tomatoes and vegetables because land for crop production was available. Moreover, some subsistence farmers used to produce more than enough crops to even sell and generate income for their household. For instance, one of the key informants, Mr Don Shivuri, whose father was a well-known farmer in Bungeni Village, pointed out that his father used to have 5 hectors-long sugarcane fields along Majirija River, wherefrom they generated significant income during harvest times. Additionally, Mr Shivuri indicated that his household used to create temporal jobs for some of the community members in the village. However, in the post-1990 period, only a few households continued practicing crop production for food security purposes. Indeed, some households are still growing few crops, particularly maize in their yards and empty spaces next to the main tarred road in the 30 villages surveyed. The agricultural land which was available is now either infertile or turned into settlement areas for households. In terms of livestock farming, the majority of households in rural Makhado Local Municipality used to have large herds of livestock which included cattle, goats, sheep, chicken and pigs. In a focus group discussion with Cattle Dip Tank operators from Hlanganani Agricultural Cost Centre, it was revealed that the majority of households used to own plenty of cattle in the pre-

1990 era. Per village service point, they used to dip more than 2000 animals with each household owning more than 200. However, in the post-1990 period, only few households still reared any type of livestock. Only few cattle and chicken, 10 on average, are kept, if any, in most households. In terms of cattle dipping, the dip tank operators highlighted that there has been a drastic decline in ownership of livestock in the villages. Most of dip tanks are no longer operating (Appendix C: Photograph 1) and increasingly fewer herds of cattle are brought to a one service point from different villages for dipping.

5.4. Main Crops and Livestock Reared in Pre- and Post-1990 Eras

As already highlighted above, the majority of households in rural Makhado Local Municipality produced a variety of crops in the pre-1990 period. Crops such as maize, ground nuts, sorghum, finger millets, pumpkins, beans, sugarcane and sweet canes among others were produced in large numbers in the villages. In that period households produced enough crops in such a way that they were required to build storages to keep their crops in order to sustain them throughout the seasons. But in the post-1990 era, it appears to have been difficult to produce crops. Only few households in the 30 villages are still producing limited number of crops such as maize and vegetables largely due to the climatic conditions that are no longer conducive food production. To be precise, rain has been so scarce in recent times that households are no longer able to even start the production process. This scenario clearly attests to what Fraser (2006) and Mkhabela et al. (2010) highlighted, as captured in chapter 2, to the effect that most African countries

are dependent on rain-fed agriculture and that recent years have been generally characterized by low and uncertain rainfall patterns and limited crop production potential. In terms of livestock, the most reared in rural Makhado Local Municipality in the pre-1990 era has been cattle, goats, sheep, chicken and pigs. However, cattle rearing dominated with an average of 200 per household. According to Mr Chauke, a retired teacher and a farmer from Mambedi Village, the majority of households particularly those who practices crop farming preferred to have more cattle and less goats and sheep because the latter used to create problems by eating crops in the fields as it is difficult to control their movements during the day. However, in the post-1990 only few households continued to rear livestock. Mr Shirinzha from Bungeni Xitachi Village, for example, used to have over 200 cattle, plenty of chicken and goats but is now left with only 10 cattle, 5 goats and 6 chickens. This scenario also confirms what Calzadilla et al. (2009) emphasized that in recent years the increase in livestock production is only found to be occurring mainly outside the traditional rural sector because of climate change as the majority of rural households are no longer able to meet the requisite preconditions for livestock production, especially grazing land and pastures for animal feed.

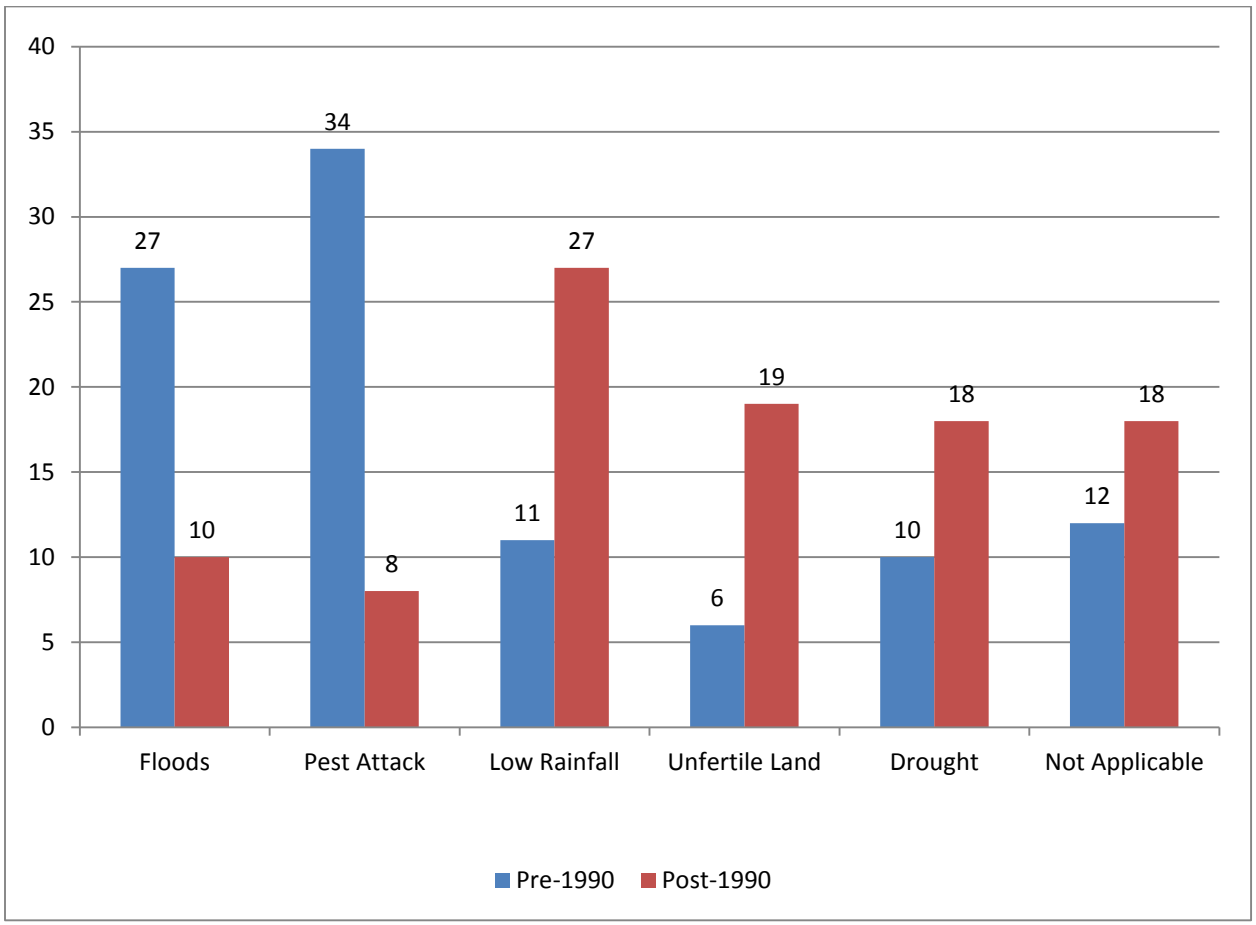
5.5. Challenges Associated with Crop Production Process in the Pre- and Post-1990 Eras

In the pre-1990 period, a reasonable percentage (34%) of respondents indicated that pests attack was one of greatest challenges that they faced when practicing crop

production (figure 5.2). Locusts and worms ate crops in the period around 1940s. One of the reasons was that as subsistence poor farmers they did not have access to pest control mechanism like commercial farmers. A marginal proportion of respondents highlighted floods as one of the major challenges that they faced. Low rainfall was also mentioned by a lower percentage (11%) of respondents. Drought and unfertile soil were also named by an even lesser proportions, 10% and 6%, respectively, of respondents; and, 12% of respondents did not practice crop production in the pre-1990 period. The impact of most of these factors was minimal because they occurred once in a while and households were still able to harvest enough crops. However, in the post-1990 era low rainfall and Unfertile land dominated the factors impacting on household food production, according to 27% and 19% of respondents, respectively. Some respondents highlighted that their crop production efforts declined drastically because of limited rainfall which has been experienced in recent years. Also, the land they relied on for crop production has been damaged and degraded because of extreme heat and soil erosion during heavy rains. These observations affirm the theoretical positioning, as reflected in chapter 2, to the effect that rain-fed agricultural food production is the only option rural households could exercise. Given the current evidence of limited precipitation and extreme drought conditions, rural households' food production efforts would be unavoidably compromised. As already mooted, some of the better-off households have resorted to building boreholes in order to have enough water to irrigate their crops and to provide for their livestock. A lower proportion (18%) of respondents mentioned that the continuous episodes of drought in recent years have rendered their effort to produce crops difficult. Furthermore, 10% and 8% of

respondents, respectively, identified floods and pest attack as the main challenges they have been facing in the post-1990 period; and, 18% of respondents stated that their households are no longer producing any crops in the post-1990 period.

Figure 5.2: Proportion of the Main Challenges Associated with Household Crop Production Process in the Pre- and Post-1990 Period



According to key informants, there were few challenges related to crop production in the pre-1990 era. Those respondents whose households practiced crop farming along

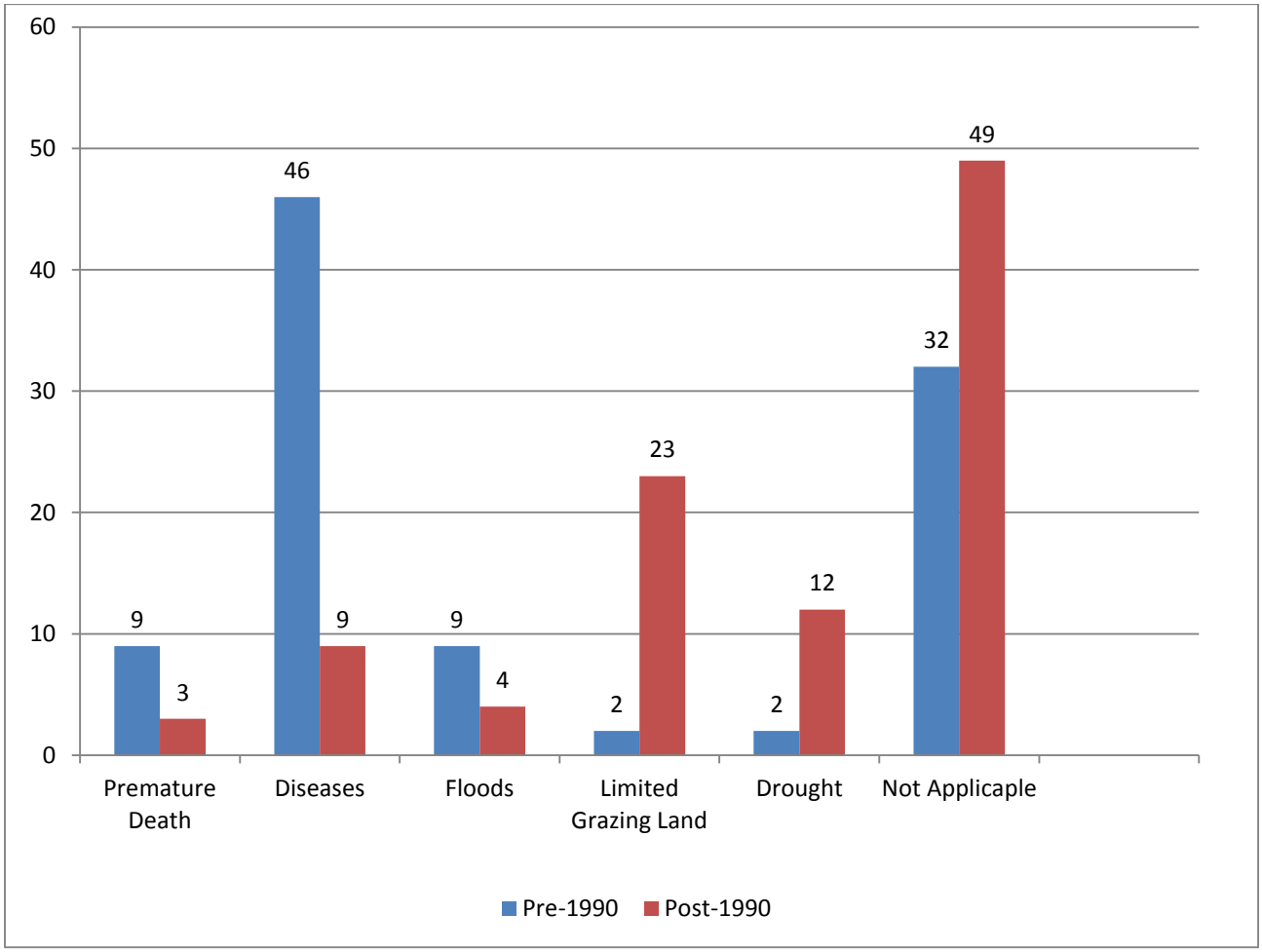
rivers in Elim Village, for example, established water catchment schemes to guarantee water supplies during dry seasons. But drought was experienced in most regions in the municipality around 1983 where households lost significant volumes of crops just before harvest. However, the post-1990 period has been generally characterised by numerous challenges pertaining to crop production, including water shortage, limited agricultural land, infertile soil and low rainfall, amongst others. The problem of water has been the most prominent, affecting food production for most households according to the majority of key informants. This observation is in line with the theoretical proposition linking water problems with many aspects of rural life support systems in recent times, inclusive of natural habitats, ecosystems, economic and social as well as agriculture and transportation (Farooq et al., 2009). For instance, Mr Tivani who is an Extension Officer at Hlanganani Agricultural Cost Centre, mentioned that water and limited rainfall have been the biggest problems affecting food production among most households in the villages in recent times. Consequently, the Centre and some better-off households in the areas had to build boreholes in order to access water for crop irrigation (Appendix C: Photograph 8 and 9). The problem of limited access to agricultural land is said to be reinforced by population growth, which expands the residential areas into pristine lands that could have been used for productive purposes (Appendix C: Photograph 4). Furthermore, extreme land degradation occasioned, among other things, by soil erosion and extreme heat was mentioned as one of the major challenges in the post-1990 era.

5.6. Challenges Associated with Livestock Rearing in the Pre- and Post-1990 Period

The majority of respondents stated that one of the main challenges they faced in livestock rearing during the pre-1990 period was the spread of different diseases that they could not control. Additionally, most households in rural Makhado Local Municipality were poor subsistence farmers who could not afford veterinary medication to prevent and control livestock diseases. However, a few respondents (9%) mentioned that both premature deaths and floods posed main challenges for households (figure 5.3). Furthermore, a negligible proportion of respondents (2%) mentioned limited grazing land and drought as the challenges they faced in the pre-1990 era. That is, most climate-related challenges that households are currently facing were not viewed as significant by the majority of households in the pre-1990 period. A relatively significant percentage (32%) of households did not practice livestock rearing in the pre-1990 era. According to 23% of respondents, limited grassing land has been one of the main challenges households faced in rearing livestock during the post-1990 period. Presently, the 30 villages no longer have lands specifically demarcated for purposes of livestock grazing. Twelve percent of respondents mentioned that there were episodes of extreme drought which posed challenges. Circumstances of extreme heat, together with limited precipitation in recent times have led to death of most livestock. Additionally, disease, floods and premature livestock death, as mentioned by 9%, 4% and 3% of respondents, respectively, were among the prominent challenges in the post-1990 period. Perhaps, these challenges explain why 49% of respondents indicated that their households did not practice any form of livestock rearing in post-1990 era. It is

understandable why most households could have lost interest in livestock rearing post-1990.

Figure 5.3: The Proportion Main Challenges Associated with Household Livestock Rearing Process, Pre- and Post-1990



According to some key informants pre-1990 livestock rearing in rural Makhado Local Municipality challenges were associated with the establishment of the Apartheid Transvaal Council (TC), which controlled livestock farming. According to Mr Chabalala, a retired Police Officer and former subsistence livestock farmer from Mashau Doli

Village, TC controlled the number of cattle each farmer could herd and non-compliance was sanctioned with enforced auction. Ironically, only white local farmers were allowed to bid at the auction with a limited amount of sale income given to the subsistence farmer, notwithstanding the implications of non-compliance with TC regulations. However, post-1990 challenges with livestock farming were numerous, diverse and severe, as attested to by all key informants. Lands, if any, zoned for livestock in the 30 villages grazing are typically dry with sparse vegetation (Appendix C: Photograph 3), and some already converted into residential sites, as already stated (Appendix C: Photograph 4). Presently, animals roam around the village's residential areas destroying vegetables from household gardens, flowers and domesticated plants as well as drinking from water spillage pools around communal taps (Appendix C: Photograph 5 and 6). According to most key informants, the costs of rearing livestock, specifically cattle, currently is excessively high. For instance, Mr Chabalala emphasized that in recent times, rearing livestock came to require access to veterinary medication such as regular injections to prevent bacterial infections, as well as artificial fodder for feeding during dry seasons. Furthermore, the majority of cattle owners are elderly people who cannot take care of livestock by themselves; as a result, need to hire herd men. The majority of such elderly livestock owners are pensioners with severely limited incomes to afford employing herd men. Unsurprisingly, key informants noted increasing incidence of livestock theft in the 30 villages. The environmental difficulties associated with livestock rearing in post-1990 as well as the associated high costs could have precipitated thieving among communities, as a matter of sheer frustration. Overall, the

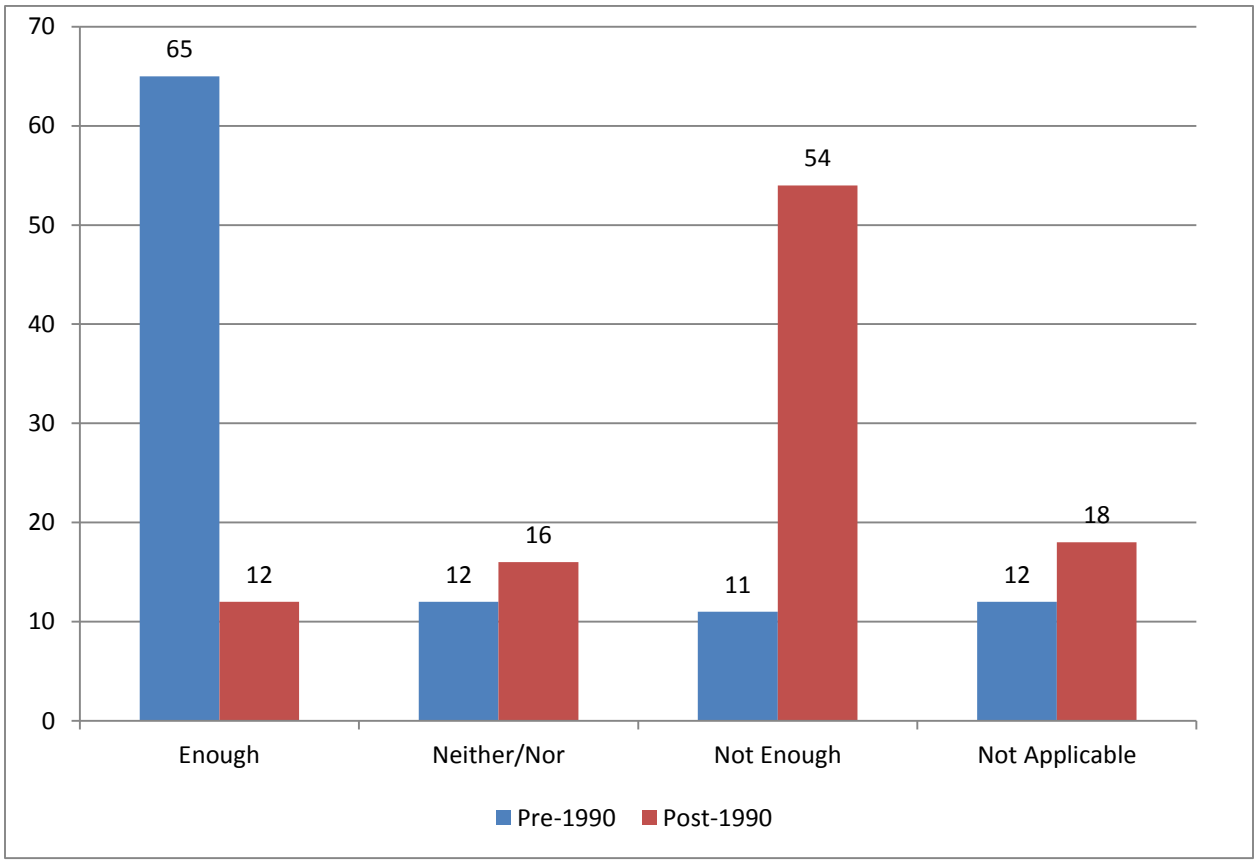
pre-1990 period was, compared to post-1990, relatively favourable in terms of household food production practices.

5.7. Household Crop Yield: Pre- and Post-1990

The majority of household respondents (65%) mentioned that the crop yields produced were enough in the pre- 1990 era (Figure 5.4). For example, every household harvested tons of maize in each production season. The harvest catered for the household food requirements beyond four seasons of the year. A negligible proportion (12%) of respondents stated that they were not sure if the crop yields were enough, whereas, similarly a negligible proportion (11%) mentioned that the crop yields were not enough in the pre-1990 period. Furthermore, 12% of the respondents mentioned that the households are no longer practicing crop production. Unfortunately, there has been a drastic change on the crop yields in the post-1990 era. The majority of household respondents (54%) stated that the crop yields have declined in the post-1990 era. Some of the reasons for this decline include limited access to fertile land for production and lack rainfall and/or water for irrigation. A negligible proportion of respondents (16%) mentioned that they were not sure if the crop yields were enough in the post-1990 era, whereas, a further negligible proportion (12%) of the respondents mentioned that the crop yields were not enough. Most of the households who still get enough crop yields are those who have established boreholes and irrigate the crops in their yards. Ironically, only the better-off households have boreholes which enables them to irrigate the crops comparing to the poor households who practiced food production for survival

and do not have access to water. A less significant proportion of respondents (18%) mentioned that the households have abandoned crop production activities in the post-1990 era.

Figure 5.4: The proportion of the Crops Yields the Household Produced in the Pre- and Post-1990 Period



In terms of community wide levels of crop yields as outlined by the key informants, the majority of households produced more than enough crops to sustain the households' food requirements throughout the seasons in the pre-1990 era. For example, one of the key informants mentioned that in Mashau Doli Village households harvested on average

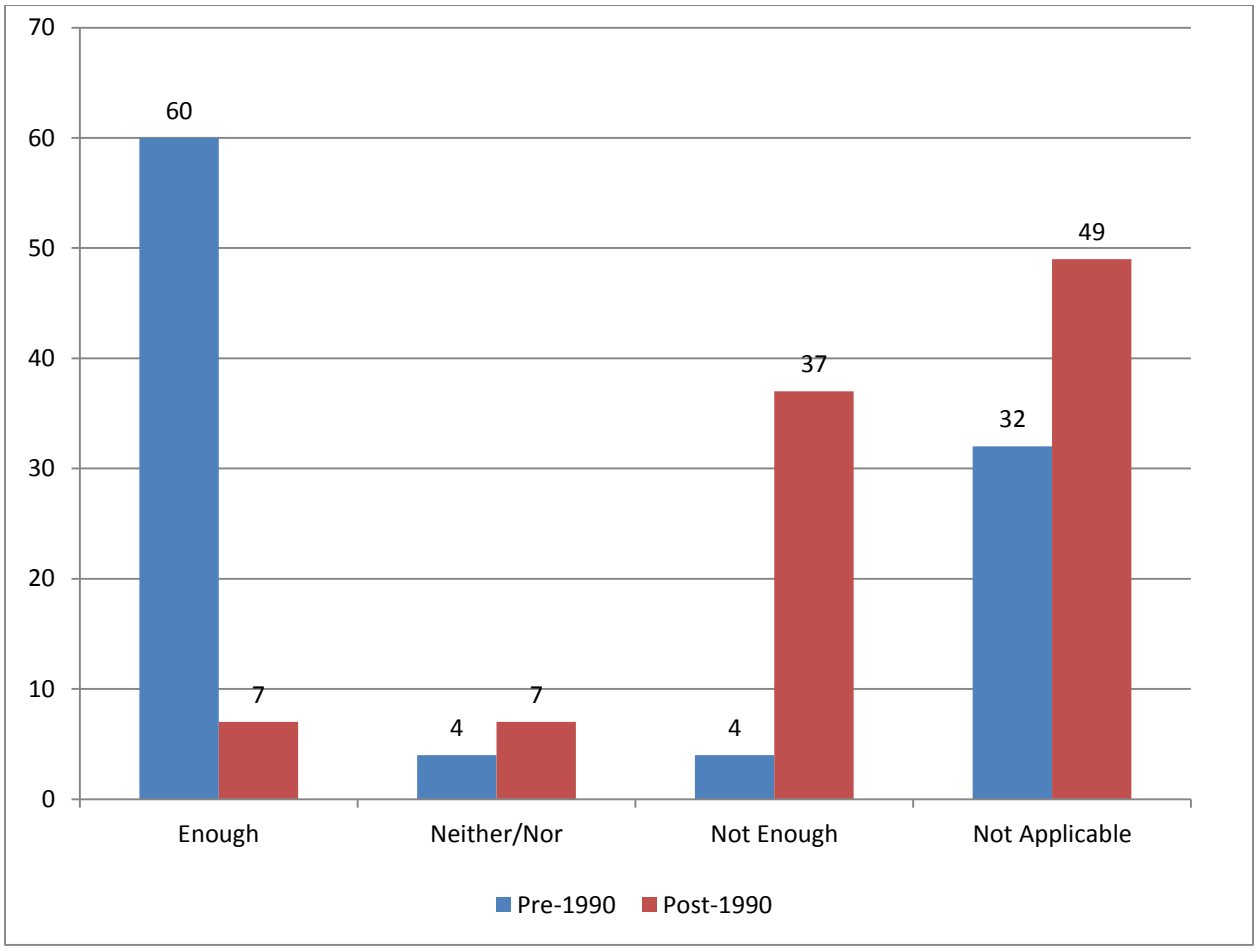
200 kilograms of ground nuts each year. Interestingly, most of the harvest made was only used for subsistence purpose and at times shared with friends and relative. Due to the high levels of crop yields, most of households built different traditional storage facilities such as Nkundla/Dulu (Xitsonga/Tshivenda) to store and protect the crops. Some of these facilities were built strategically underground inside a house where the household made fire and other storages were built outside on top of rocks. The reason for this specific building measure was to protect crops from insects and small animals such as rats. Different crops produced by households were used to cook different kinds of traditional food stuff such as Tshidzimba (Tshivenda) which was prepared using a mixture of maize, beans and ground nuts. Furthermore, in Mr Shivuri's household, the vast sugarcane harvest was sold and generated income at the local sporting activities and at times exported from the village to the Zion Christian Church (ZCC) in Polokwane Municipality. Additionally, at the Hlanganani Agricultural Cost Centre they used to produce enough crop yields and sell to the communities around. However, in the post-1990 era the levels of crop yields in the 30 villages declined according to the key informant. The circumstances surrounding this decline was affirmed by Parry et al. (2004) and Abraha & Savage (2006) who argued that the higher temperatures and changing precipitation levels resulting from climate change are depressing crop yields and causing limited harvest especially in most low-income countries, where adaptive capacity is low. Currently, few households are still practicing crop production with a noticeable limited harvest. However, Most of the households are currently bound to purchase staple food such as maize meal from retailers in order to supplement the limited crop yield that they harvest. Contrary to the situation pre-1990 period where

households produced variety of crops, in post-1990 era only the sum of maize crops and beans are dominantly produced.

5.8. Household Livestock Yield: Pre- and Post-1990

In the pre-1990 era the majority of household respondents (60%) mentioned that livestock yields produced were enough (Figure 5.5). Apparently, there were households who did not know the exact number of the livestock they were rearing due to the high numbers available. The livestock reared were also healthy and provided fresh meat when slaughtered for consumption. Furthermore, livestock such as cattle and chicken produced fresh milk and eggs respectively. However, a negligible proportion (4%) of respondents stated that they were not sure if the livestock yields were enough, and, similarly a negligible proportion (4%) of respondents stated that the livestock yields were not enough. A relatively significant proportion (32%) of respondents did not practice livestock rearing in the pre-1990 era. In the post-1990 period a significant proportion of respondents (37%) mentioned that there was a huge decline in livestock yields. Most households who reared about 200 cattle in the pre-1990 are no longer rearing any cattle. Those households who still rear cattle are having limited number with an average of 10. About 7% of the households were not sure if the livestock yields were enough or not and similarly, 7% of the respondents mentioned that the livestock yields were enough.

Figure 5.5: Household Livestock Yield, Pre- and Post-1990 Period



Similar sentiments on levels of livestock yields were shared by both respondents and key informant in terms of the situation in the 30 villages of rural Makhado Local Municipality. According to the key informant, in the pre-1990 era, households in the community reared large herds of livestock which did not only produced meat but other by-products such as milk and eggs. Due to large herds of livestock reared, some of the households sold them to be slaughtered when there were traditional ceremonies, funerals and weddings in the community. However, in the post-1990 era there was a significant decline in livestock rearing in the 30 villages sampled according to key

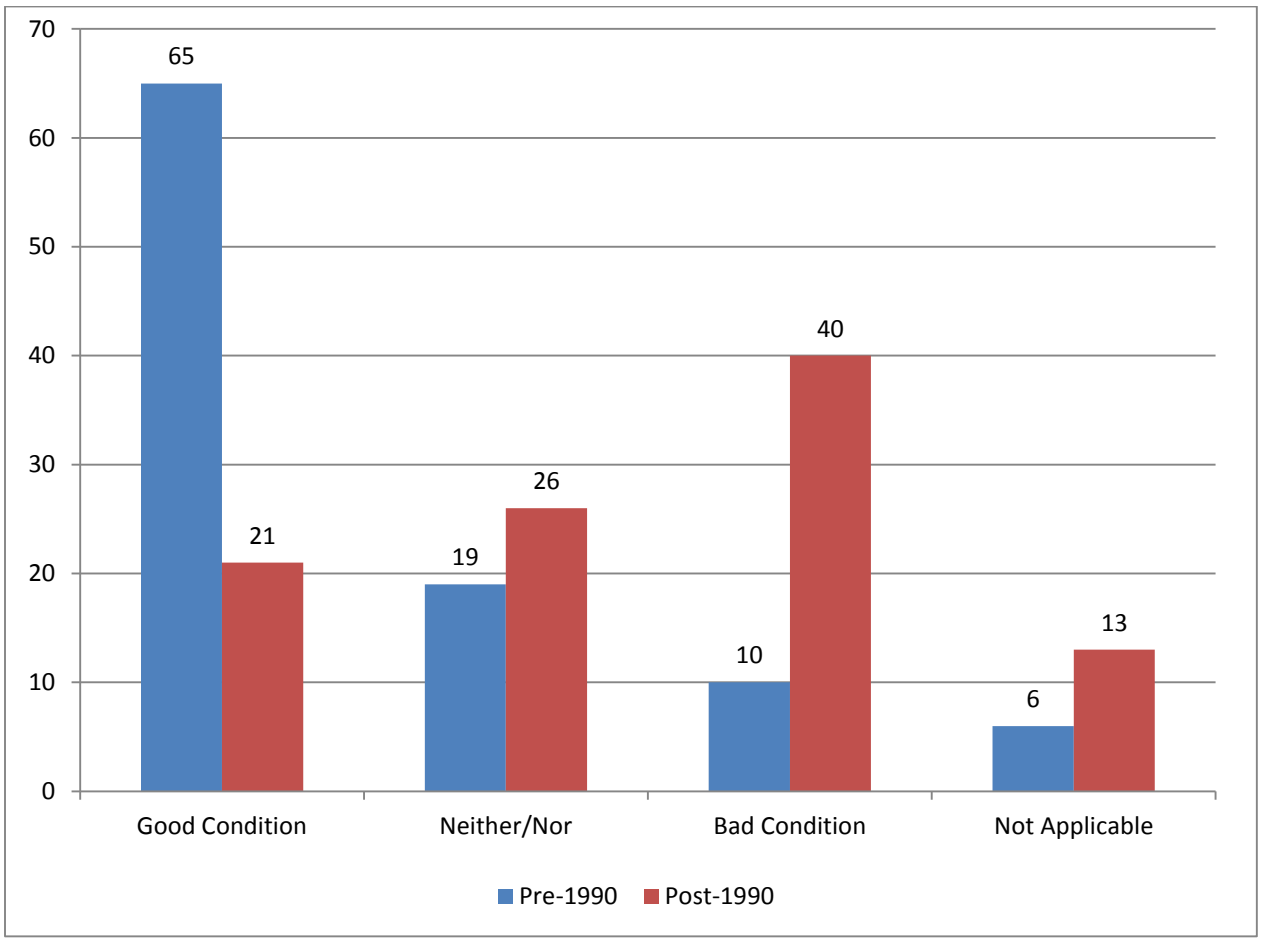
informants. The households who still rear livestock possess between 1 and 20 cattle with an average of 10. Most of the meat, milk and eggs required for the household consumption are currently purchased from local retailers. Additionally, one of the key informants from Matsila Village mentioned that in recent times, the rearing of livestock such cattle is no longer done for household food security purpose; rather, it is a practiced mostly done by senior citizens as a sense of pride for ownership without any significant benefit.

5.9. Environmental Conditions at Food Production Sites, Pre- and Post-1990 Period

In rural Makhado Local Municipality the majority of household respondents (65%) mentioned that the environmental conditions at the site where they produced food were good in the pre-1990 period (Figure 5.6). The land was always in a good condition and did not require any application of supplements such as manure. Furthermore, the site where livestock graze was always having suitable grass for livestock feed. Most of the rivers in the villages were always having water for irrigation of crops and vegetable gardens and for livestock to drink. The circumstance within the 30 villages affirms the theoretical proposition in chapter 2 which stated that environmental conditions in rural areas play a major role in determining the ability of households to produce their own food (Morvaridi, 1998; Barbier, 2000; Ramoliya, Patel, Pandey, 2004; Bugri, 2008; Titilola & Jeje, 2008). A less significant proportion (19%) of respondents stated that they were not sure if the environmental conditions were good or bad, whereas, a negligible

proportion (10%) of households' respondents stated that the environmental conditions at the site where they produced food were bad during the pre-1990 period. A further negligible proportion (6%) of respondents was those who did practice any of the food production activities in the pre-1990 period. The environmental conditions seem to have changed drastically in the post-1990 era in the 30 villages.

Figure 5.6: Assessment of Environmental Conditions at Household Food Production Sites, Pre-and Post-1990 Period

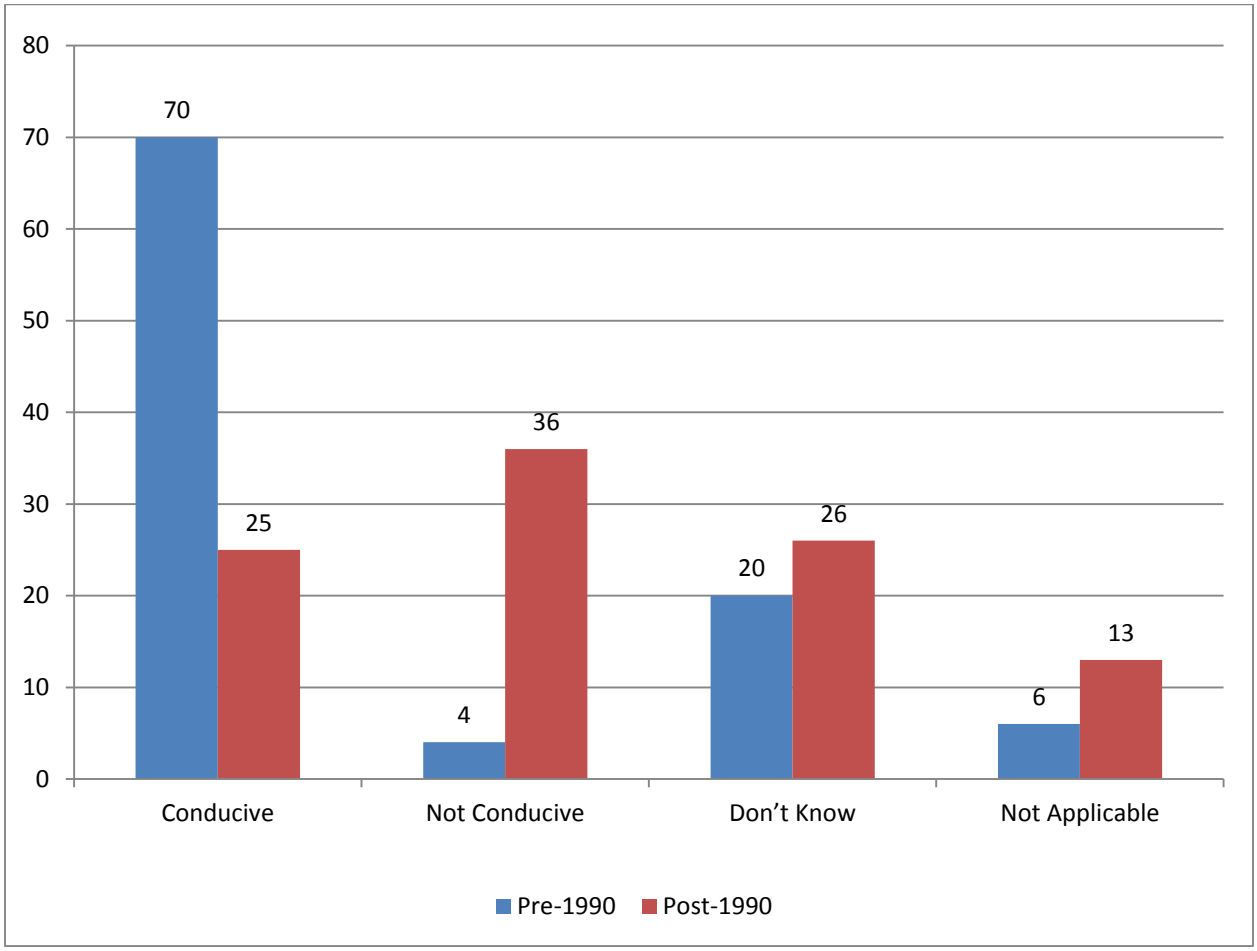


A significant proportion of household respondents (40%) mentioned that the environmental conditions of the site where they produced food were bad. Some of the reasons given were that the soil in the area is less fertile and the availability of water for crops, vegetable and livestock is scarce. A less significant proportion (26%) of respondents stated that they were not sure if the environmental conditions of the site where they produce food were good or bad. Similarly, a less significant proportion (21%) of respondents mentioned that the environmental conditions were good for food production in the post-1990 era. Thirteen percent of the respondents are those who have totally abandoned all forms of food production activities. The analysis of the key informant's supports the household sentiments in that the majority mentioned that the environmental conditions in the site where community members practiced food production has changed drastically and are no longer conducive in the post-1990 period. For instance, in Mambedi Village majority of households including individuals from local schools produced crops and vegetable in the wetlands next to the river banks of Levubu, Ketlane and Mambedi. However, in the post-1990 the environmental conditions have changed and most of the rivers have dried up. Furthermore, the soil at the wetland next to the river is degraded because of the recent excessive temperatures and soil erosion. For the households who continue to produce, including the extension officers at Hlanganani Agricultural cost Centre, they are inevitably bound to apply supplementation in the soil in the form of traditional manure. Consequently, the sugarcane fields in Bungeni Village owned by Mr Don Shivuri were less productive in recent times. Since the late 1990's, the Majirija River has shrunk into a narrow stream with limited water to extract for irrigation (Appendix C: Photograph 7).

5.10. Conduciveness of Environmental Conditions for Food Production, Pre- and Post-1990

It is not surprising to learn that a large majority of household respondents (70%) mentioned that the environmental conditions of the site where they produced food were conducive for production in the pre-1990 period (Figure 5.7). In the sense that, most of the household respondents already mentioned that, the environmental conditions of site where they produced food were good; thus, they produced high levels of crop yields and rear large herds of livestock. A less significant proportion (20%) of respondents stated that they did not know if the environmental conditions were conducive, whereas, a negligible proportion (4%) of respondents stated that the environmental conditions of the site where they produced food were not conducive in the pre-1990 era. Similarly, a negligible proportion (13%) of respondents did not practice food production activities in the pre-1990 period. In terms of the conduciveness of the environmental condition at the site where households produce food in the post-1990 period, a reasonably significant proportion (36%) of respondents stated that the environmental conditions at the site were no longer conducive. Varieties of factors are attributed to this change by key informant, for example, issues such as land degradation and loss of soil nutrients. These circumstances attest to what Muchenaa et al. (2005) and Nyssen et al. (2009) argued in chapter 2 when they stated that, whereas onsite impacts of land degradation are immediately felt by the farmers. The overall impact is much wider than the sum of individual losses or benefits.

Figure 5.7: Perceptions of Conduciveness of Environmental Conditions for Food Production, Pre- and Post-1990



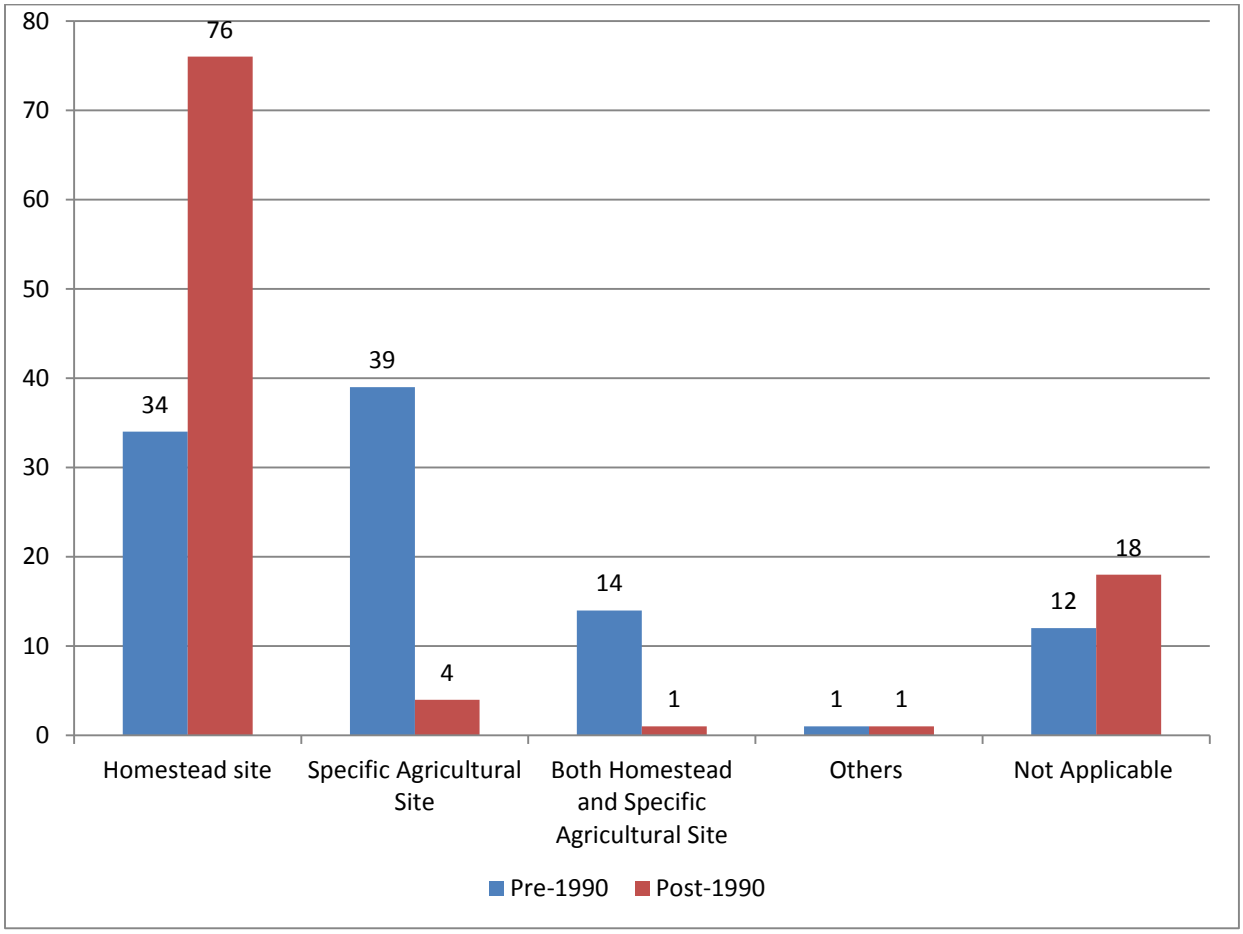
In many instances, farm sizes, especially in the high-potential areas, have been reduced to the point where adequate living can only be obtained if land is farmed intensively and if there is an off-farm income as an option. A less significant proportion (26%) of the respondents mentioned they were not sure if the environmental conditions were conducive or not, whereas, a further less significant proportion (25%) stated that the environmental conditions of the production site were conducive. However, most of these respondents confirmed that they apply soil supplements and irrigation systems for

the crops (Appendix C: Photograph 8 and 9). A negligible proportion (13%) did not practice any of the food production activities in the post-1990 period.

5.11. Household Site for Crop Production, Pre- and Post- 1990 Period

As it is already stated in the previous sections of this analysis, majority of households in rural Makhado Local Municipality had access to enough land for both crop production and livestock rearing in the pre-1990 era. Due to the abundance of land for production, households produced plenty of crop and livestock yields to consume throughout the seasons including in times of drought and limited rainfall. This situation is clearly demonstrated by the fact that 36% of the households practiced food production in a specific agricultural land in the pre-1990 era (Figure 5.8). Similarly, a relatively significant proportion of the respondents (34%) stated that they produced food in homestead. Only a negligible proportion of respondents (14%) mentioned that they practiced crop production in both the homestead yards and a specific agricultural site. Most of the households who practice in both the homestead and specific agricultural site are those who had large numbers of household members available to provide man power when cultivating. A negligible percentage of 1% and 12% are those who practiced in other areas such as small patches of land next to the tarred roads and those who did not practice crop production in the pre-1990 period respectively. Comparing the situation pre- and post-1990, it is clearly observable that the majority of households who had access to land beyond their homestead are no longer having access in recent times.

Figure 5.8: Household Food Production Site, Pre- and Post-1990

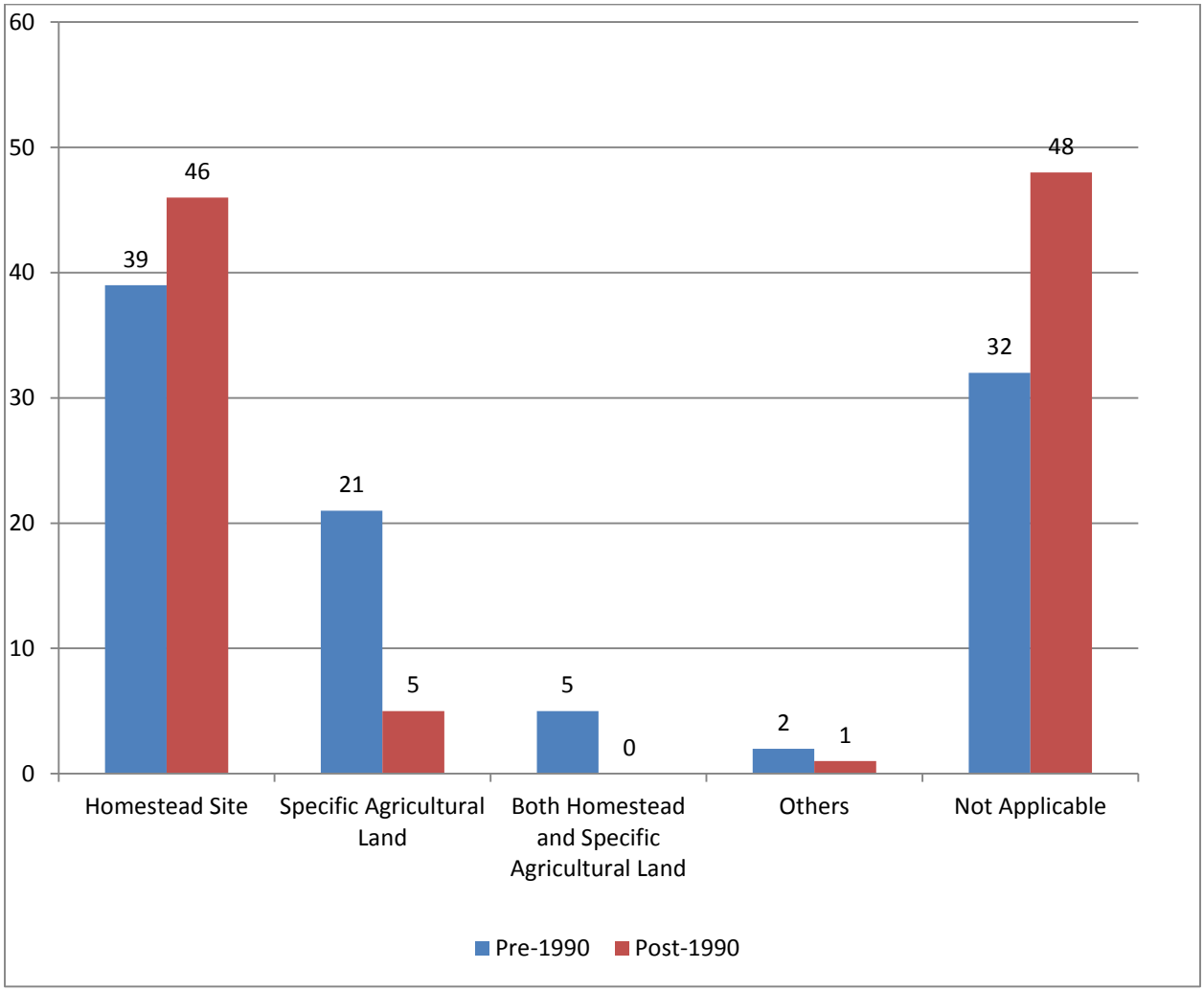


The majority of respondents (76%) stated that they produce crops in the homestead and that the harvest has declined severely in the post-1990 era (Figure 5.8). Most of the factors contributing to the decline in access to land have already been outlined as land degradation and expansion of human settlements. A negligible percentage of 4% and 1% of respondents stated that they still practice crop production in specific agricultural site, whilst, other households practiced in both homestead and specific agricultural site respectively. Furthermore, negligible proportions (18%) of the respondents are those who have entirely abandoned the crop production practice in post-1990 era.

5.12. Household Livestock Rearing Site, Pre- and Post-1990

The situation has not changed much when comparing the site where households practiced crop production and livestock rearing in the pre- and post-1990 eras. A relatively significant proportion (39%) of respondents mentioned that they reared livestock in the homestead during the pre-1990 era (Figure 5.9). Even though they possessed a variety of livestock of different kinds, the homestead yards were big enough to accommodate them. However, a less significant proportion (21%) of respondents stated that they reared livestock such as cattle, goats and sheep in a specific agricultural site. Only a negligible proportion (5%) of respondents mentioned that they reared livestock both at home and in a specific agricultural site. Most of these households are those who reared a variety of livestock such as chicken and pigs which were reared at the homestead and cattle and goats which were reared at the specific agricultural site. Furthermore, a negligible proportion (2%) of respondents mentioned other places which were not specified, whilst, a less significant proportion (32%) were those who did not rear livestock in the pre-1990 era. In the post-1990 period there are many factors mentioned by respondents which have contributed to the decline of livestock rearing process in 30 villages of rural Makhado Local Municipality. Factors such as high levels of livestock theft, lack of water in the rivers for livestock to drink and limited spaces for grazing. In that sense, a significant proportion (46%) of respondents mentioned that they reared livestock at the homestead. Drawing from the analysis in the previous sections, it is understandable because most of households are currently rearing a limited number of livestock.

Figure 5.9: Household Livestock Rearing Site, Pre-and Post-1990

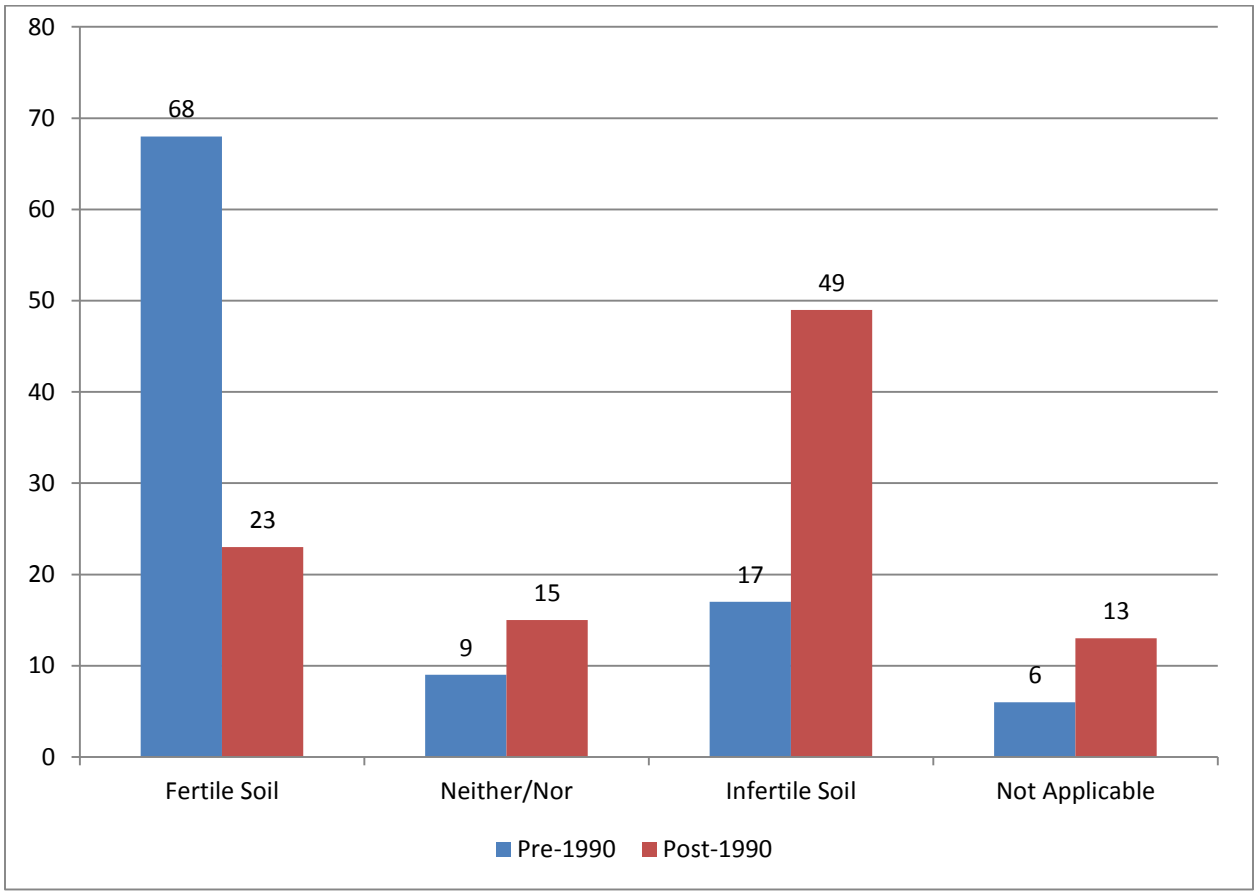


A Negligible proportion (5%) of respondents mentioned that they reared livestock in a specific agricultural site, whereas, a negligible proportion (1%) of respondents stated that they reared in others unspecified sites. Consequently, a significant proportion (48%) of the respondents mentioned that they were no longer practicing livestock rearing in the post-1990 era.

5.13. Soil Conditions at Household Food Production Sites, Pre- and Post-1990

One of the most important aspects which determines the success and lack thereof of food production particularly in rural areas is the soil conditions in the site where crops are produced and livestock grazed. In this instance, the majority of respondents (68%) stated that in the pre-1990 period, the soil was very fertile in the site where they produced food (Figure 5.10). Plenty and variety of food products where produced in these sites without the use of any soil enhancement.

Figure 5.10: Soil Conditions at Household Food Production Sites, Pre-and Post-1990



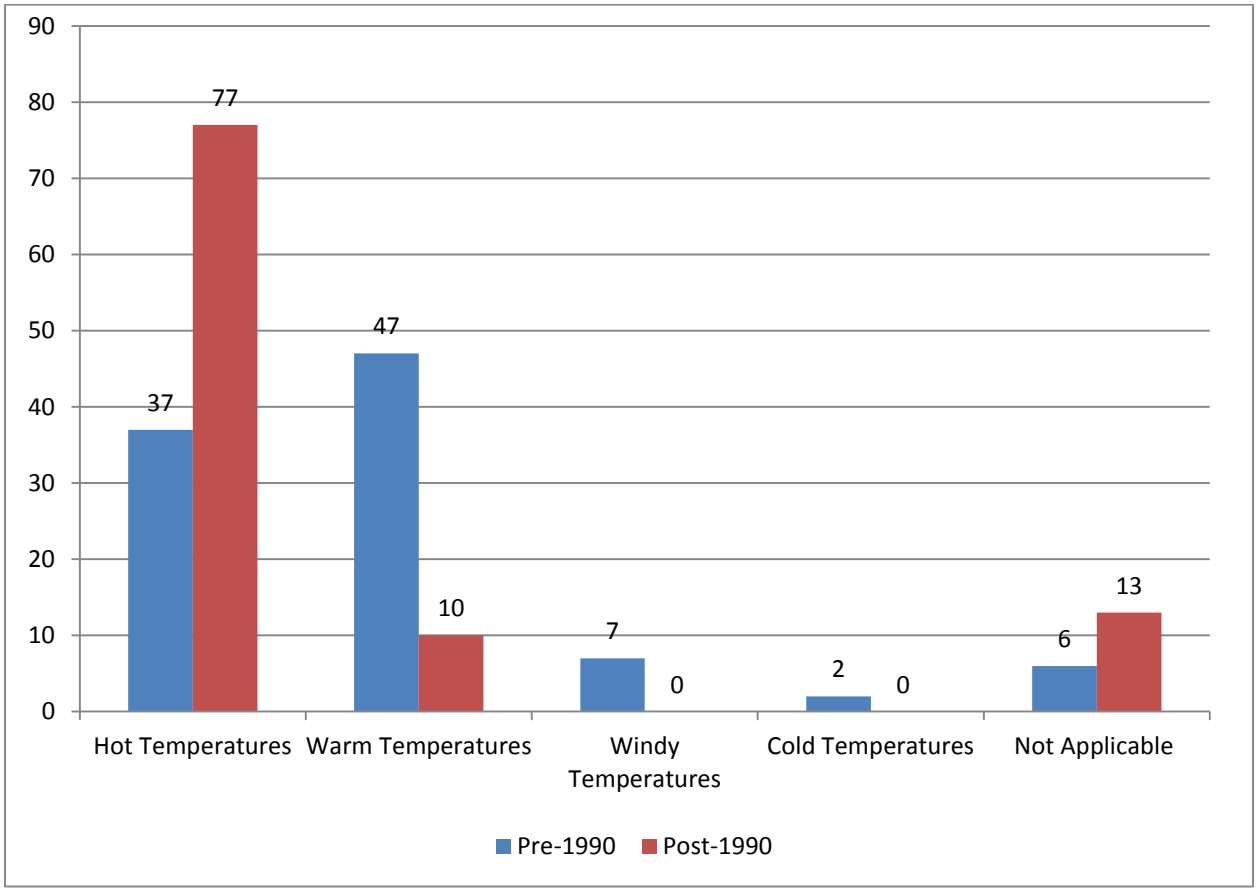
A less significant proportion (17%) mentioned that the soil in the site where they produced food was infertile, whilst, only a negligible proportion (9%) of the respondents stated that they were not sure if the soil was fertile or not. Similarly, a negligible proportion (6%) of respondents did not practice food production activities in the pre-1990 period. In the post-1990 period the soil condition changed drastically in the 30 villages of rural Makhado Local Municipality. A significant proportion (49%) of respondents mentioned that the soil condition in the site where they produce food was no longer fertile. Most of these respondents were from poor households who were practicing food production activities for survival and who are largely dependent on this process for food security. This circumstance affirm what Yesuf et al. (2008) stated when he said that, there intensification of agricultural production for survival has led to natural resource degradation, as desperate poor farmers, mine soil fertility climb the hillsides in an effort to survive. However, a less significant proportion (23%) of respondents stated that the soil in the site where they produce food was fertile. Similarly, a less significant proportion (15%) of respondents mentioned that they were not sure if the soil was fertile or not. Only 13% of the respondents are those who were not practicing food production in the post-1990 era.

5.14. Common Temperature Patterns in the Pre- and Post-1990 Era

In any successful agricultural production circumstance, for a good and fertile soil to continue and create a sustainable production of crops and vegetable, good temperature patterns are required throughout the growing stages of the crops until its harvesting

time. Thus, good temperature patterns are the second most important ingredient for household food production process. In the pre-1990 period, a significant proportion (47%) of the respondents stated that the temperatures were warm in the site where they produced food during the production times Figure (5.11). This was good for crops because the temperatures were moderate and there were enough precipitation for plants growth. However, in other areas of the 30 villages sampled at the municipality a relatively significant proportion (37%) of respondents mentioned that the temperatures were hot in the pre-1990 era.

Figure 5.11: Common Temperature Patterns at Household Food Production, Pre- and Post-1990



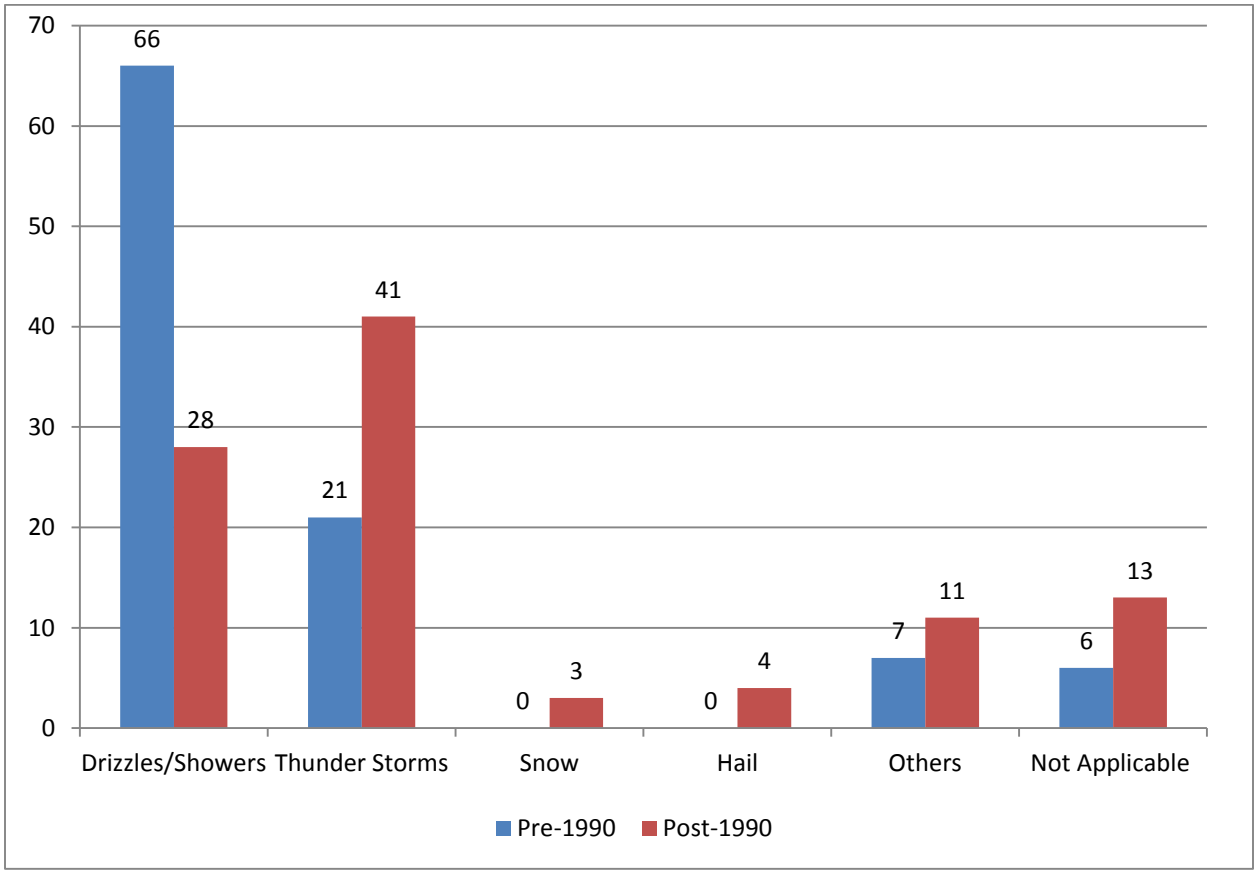
Only negligible percentages of 7% and 2% of the respondents stated that the site where they produced food experienced windy and cold temperatures respectively. Additionally, a negligible proportion (6%) of respondents was those who did not produce food in the pre-1990 period. Unfortunately, in the post-1990 era the temperature patterns changed and were not conducive for food production. The large majority of respondents (77%) mentioned that they experienced excessive heat as a common temperature feature at the site where they produced food. This coupled with erratic rainfall rendered the efforts to practice food production futile. Only a negligible proportion (10%) of respondents mentioned that they experience warm temperatures in the site where they produce food, whilst, a further negligible proportion (13%) of respondents mentioned that they did not practice food production activities in the post-1990 period. The issue of changing temperature in rural Makhado Local Municipality affirms the theoretical opinion as stated by Khan & Usmani (2005) when they argue that, increasing temperature because of climate change is not only affecting crops but also it has implied the potential increase in animal diseases due to the shift of pathogens to more favourable host environments (e.g. multiplication of pathogens in animal feed).

5.15. Common Precipitation Patterns in the Pre- and Post-1990 Era

Adding to the pool of important factors which determine a successful agricultural production particularly in rural areas where they practice rain-fed subsistence agriculture is the common precipitation patterns which might be faced in such an area. In 30 villages of rural Makhado Local Municipality, the majority of respondents (66%)

mentioned that the area experienced enough and consistent drizzles and showers which were good for production in the pre-1990 era (Figure 5.12). The precipitation in the form of drizzles and showers was reliable and enabled households to grow different crops with a successful harvest almost every year. However, a less significant proportion (21%) of respondents mentioned that they commonly experienced thunderstorm precipitation at the site where they produced food. Additionally, a negligible proportion (11%) of respondents mention other unspecified precipitation patterns, whereas, a further negligible proportion (6%) did not produce food in the pre-1990 era.

Figure 5.12: Common Precipitation Patterns at Household Food Production Sites, Pre- and Post-1990



In the post-1990 period there was a significant change in precipitation patterns at the 30 villages. A relatively significant proportion (41%) of respondents mentioned that they experience more thunderstorm than before. Thunderstorms which were coupled with excessive winds destroyed a lot of crops in the area. Additionally, unlike during the pre-1990 period, a less significant proportion (28%) of respondents mentioned that they experience drizzles and showers in the post-1990 period, whereas, a negligible percentage of 3% and 4% mentioned that the experienced snow and hail respectively. Furthermore, a negligible proportion (11%) of respondents mentioned other unspecified forms of precipitation, whilst, only 13% were those who did not practice food production activities in the post-1990 era.

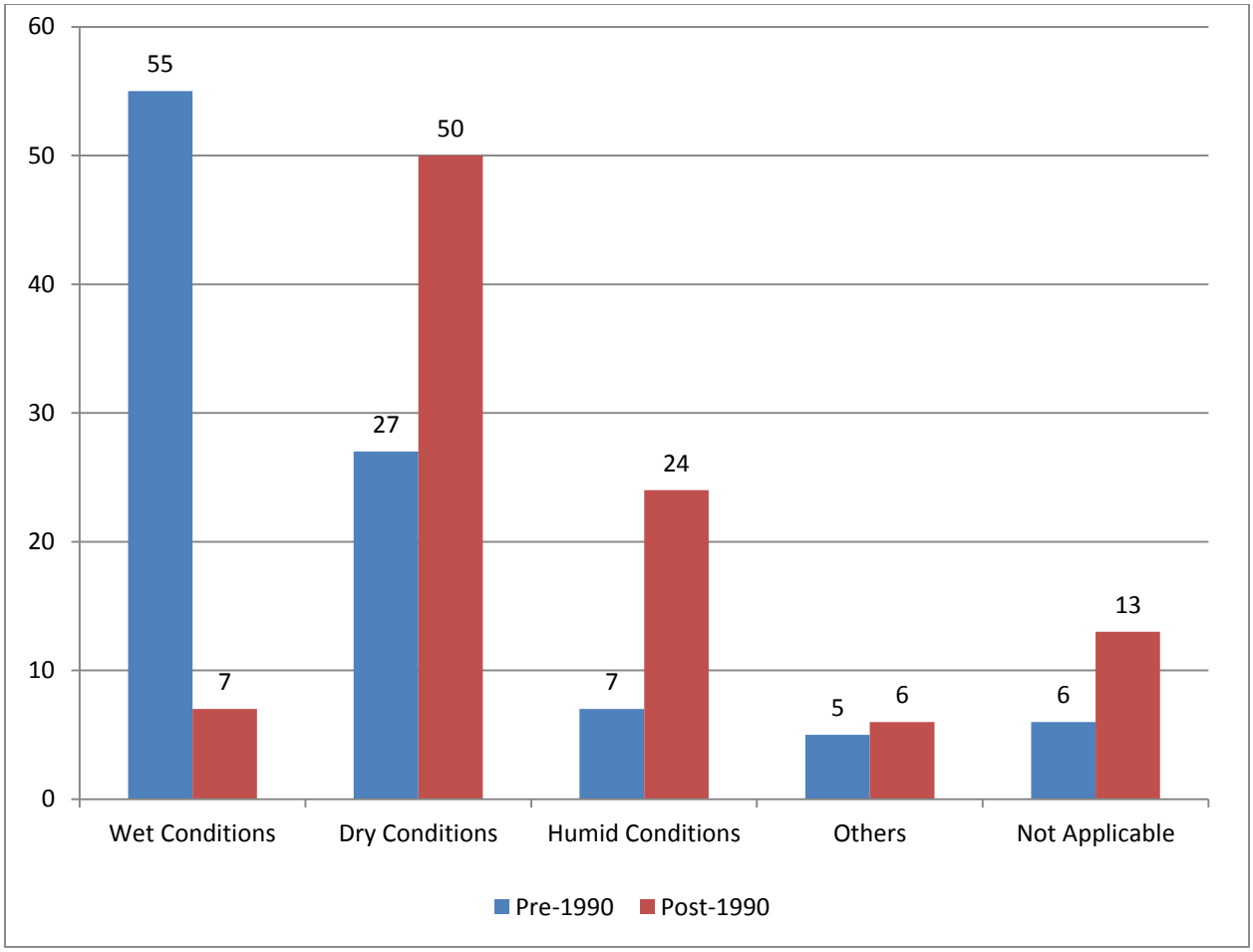
The above analysis was supported by key informants during the interviews and focus group discussion. One of the aspects which came out in almost all the discussions with the key informants was that there was enough precipitation and water for both crop production and livestock rearing in the pre-1990 era. For instance, one of the key informants mentioned that, the rainfall in the area was consistent every year and such enabled them to strategically plan for crop production in different seasons. For example, when producing maize, the community experienced the first rainfall around the month of August which prepared the soil for cultivation, during October when the seeds were already underground and throughout December and January when the plants were growing until March before harvesting. Interestingly, the availability of rainfall and water in the rivers was accompanied by good temperature patterns which were always good and conducive for crops and livestock growth. However, in the post-1990 period things

changed in that there were excessive heat, rainfall was limited and most of the big and small rivers systems dried up. The temperatures were not conducive for food production due to extremely heat which was experienced without rainfall. The drastic changes and the effects of changing precipitation and temperature patterns attests to what Tshiala & Olwoch (2010) and Rowhani et al. (2011) highlighted when they said that, the increased temperature and altered precipitation patterns have resulted in increased losses of soil minerals, especially by leaching and erosion in many rural areas.

5.16. General Climatic Conditions in the Pre- and Post-1990 Period

In the pre-1990 period the majority of household respondents (55%) mentioned that the climatic conditions of the site where they produced food were wet (Figure 5.13). This circumstance was due to the fact that the area experienced enough reliable precipitation as demonstrated in section 5.14. Crops such as maize and ground nuts had enough water and produced a successful harvest almost every year. However, a less significant proportion (27%) of respondents mentioned that the climatic conditions in the site where they produced food were dry. Nevertheless, they were still able to have successful harvest because the soil was fertile. A negligible proportion (7%) of respondents stated that the climatic conditions were humid, whereas, a further negligible proportion (5%) of respondents mentioned the combination of dry and wet conditions in the same area. Additionally, negligible proportions (6%) of the respondents were those who did not practice any food production activities in the pre-1990 period.

Figure 5.13: General Climatic Conditions at Household Food Production Sites, Pre- and Post-1990



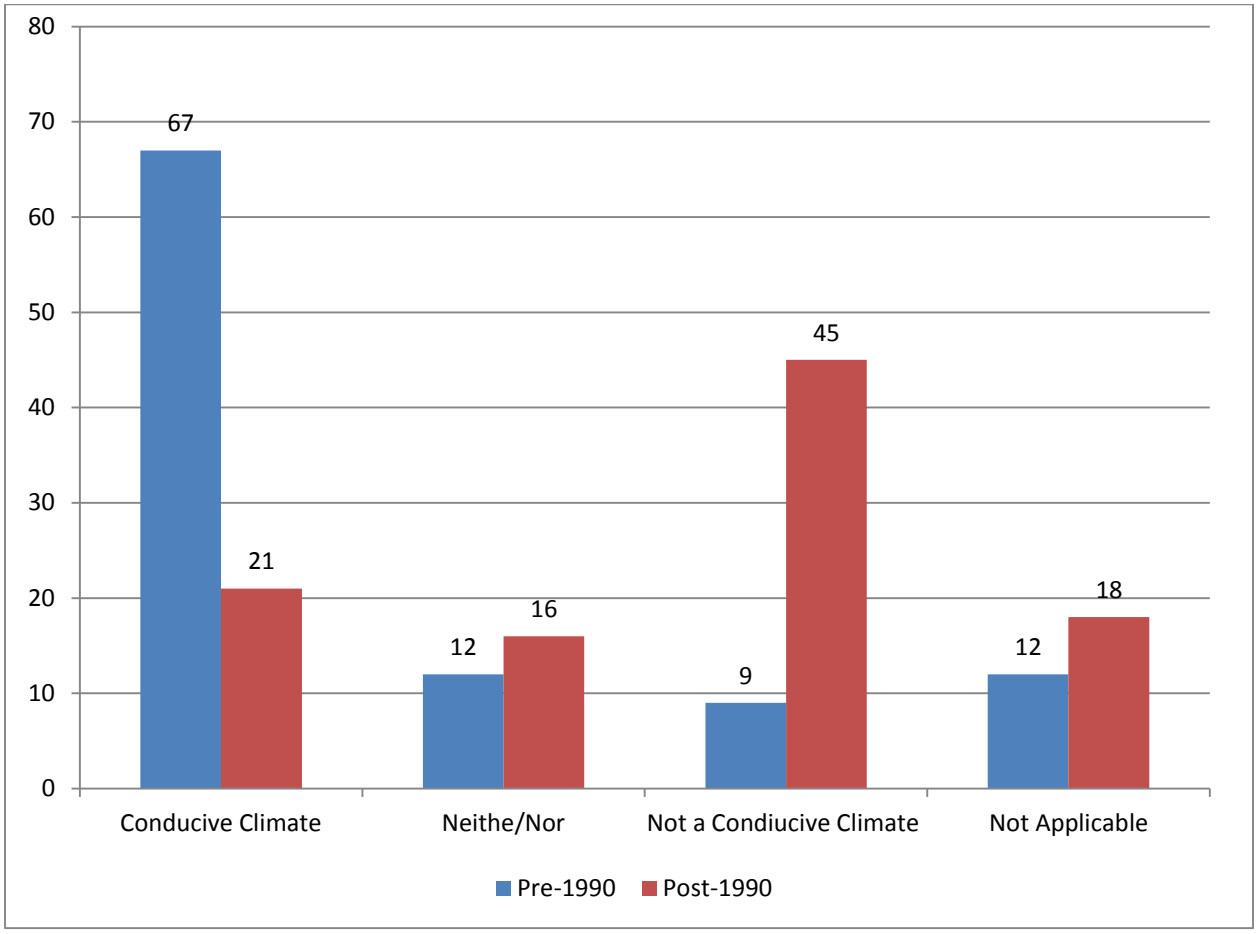
The situation shifted significantly in the post-1990 era as it was demonstrated by the significant proportion (50%) of respondents that most areas which experienced wet climatic conditions in the period pre-1990 started to experience more dry conditions in the post-1990 period. These changes led to a noticeable decline in household food production and ultimately exposed some households to food insecurity. This scenario affirm what Khandlhela & May (2006), Hahn et al. (2009) and Miraglia et al.(2009) argued when they said that, climate change effects on many rural situations influences

the decrease in the amount of yearly precipitation, prolonged dry periods and projected temperature increases which ultimately have a long impact of food production in rural areas. A negligible proportion (7%) of respondents stated that they experienced wet climatic conditions, whilst, a similar negligible proportion (7%) of respondents mentioned that they experienced humid conditions. Additionally, only 13% are those households who did not practice food production in the post-1990 era.

5.17. Conduciveness of Climatic Conditions for Crop Production, Pre- and Post-1990 Period

To certify the demonstration made in the previous section 5.16 that the climatic conditions were good for food production in the pre-1990 period, the majority of respondents (67%) mentioned that such conditions were conducive (Figure 5.14). The conduciveness of these conditions enabled households not only to produce enough crops to survive but also to store and consume during and after the year of harvest. A negligible proportion (12%) of respondents mentioned that they were not sure if the conditions were conducive or not. Most of these households are those who experienced a fluctuation of different kinds of climatic conditions. Additionally, a negligible percentage of 9% and 12% of respondents stated that the climatic conditions were not conducive and the other respondents were not practicing food production activities in the pre-1990 period respectively.

Figure 5.14: Perceptions of Conduciveness of Climatic Conditions at Sites of Household Crop Production, Pre- and Post-1990



In the post-1990 era, a relatively significant proportion (45%) of respondents mentioned that the climatic conditions were less conducive for crop production. This was due to the fact that rainy season have shifted and most of the rivers have dried up, furthermore, there were excessive episodes of crop failure and most of the livestock have died because of extreme heat. This situation affirm to what Fraser (2006) wrote when he said that, climate induced natural hazards such as drought has been more than just a simple lack of rainfall, it has negatively impacted the process of cultivating crops in such

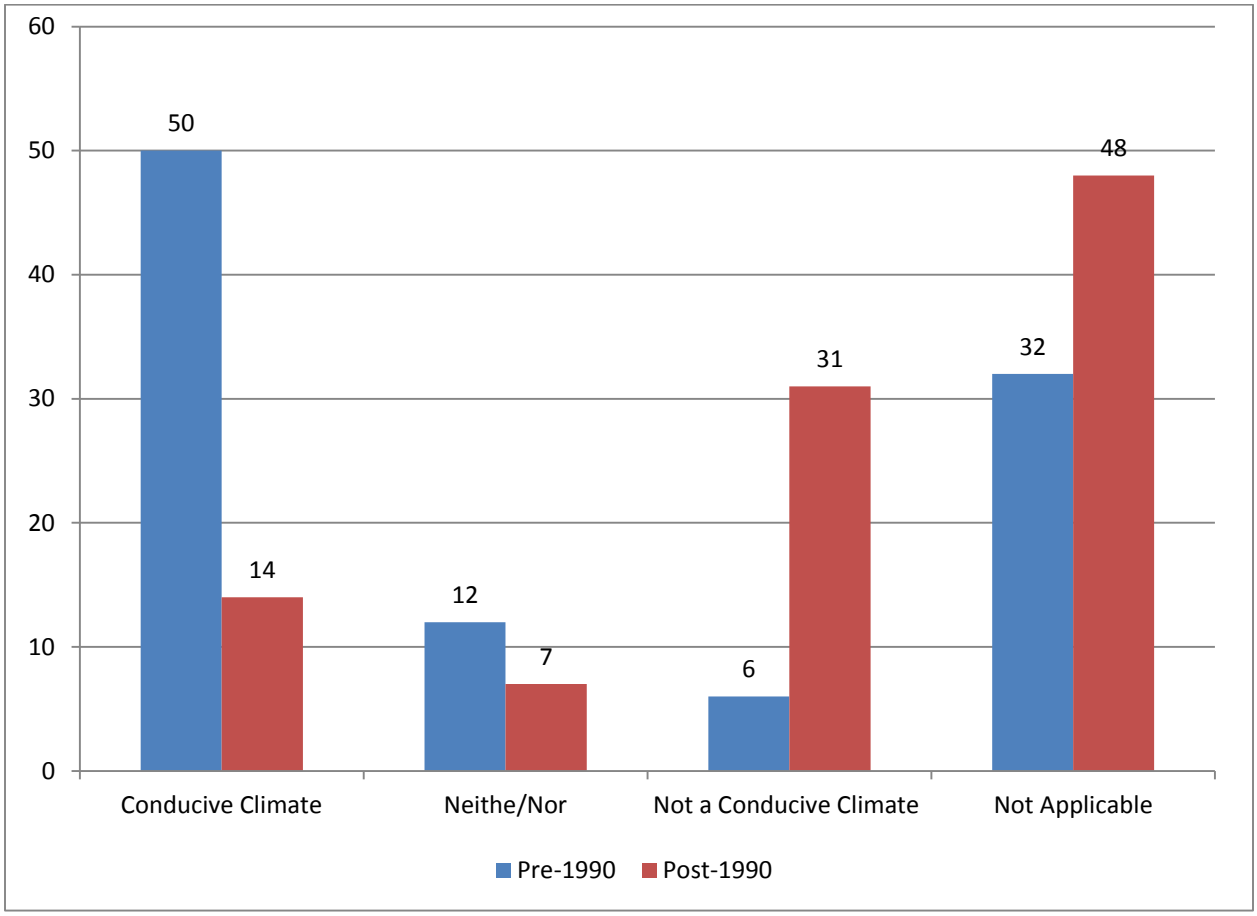
a way that the majority of rural residence are becoming food insecure. A less significant proportion (21%) of respondents stated that the climatic conditions were conducive, whereas, a negligible proportion (16%) of respondents mentioned that they were not sure if the conditions were conducive or not. Additionally a less significant proportion (18%) of respondents was those who have abandoned food production practices in the post-1990 era.

5.18. Conduciveness of Climatic Conditions for Livestock Rearing in the Pre- and Post-1990 Period

Concerning livestock rearing, a significant proportion (50%) of respondents stated that the climatic conditions at the site where they rear livestock were conducive in the pre-1990 period (Figure 5.15). In these areas, animals had access to enough grass for grazing and water for drinking. However, a negligible proportion (12%) of the respondents stated that they were not sure if the climatic condition at the site where they reared livestock were conducive or not. Similarly, a negligible proportion (6%) of respondents said that the climatic conditions were not conducive. Most of these households are those who were rearing livestock in areas which had dry conditions. Relatively significant proportions (32%) of the respondents are those who did not rear livestock in the pre-1990 period. In terms of the climatic conditions in sites where households practice livestock rearing, it was clear that the circumstance have changed in the post-1990 period. At this period, relatively significant proportion (31%) of

respondents mentioned that the climatic conditions of the site where they rear livestock were not conducive.

Figure 5.15: Perceptions of Conduciveness of Climatic Conditions at Sites of Livestock Rearing, Pre- and Post-1990



Excessive heat which led to dryness has destroyed the pastures for grazing and the rivers where livestock drank water were no longer flowing. This situation attest to the documented literature in chapter 2 where it was stated that climate change induced floods and drought are not only undermining farm yields, killing animals and reducing

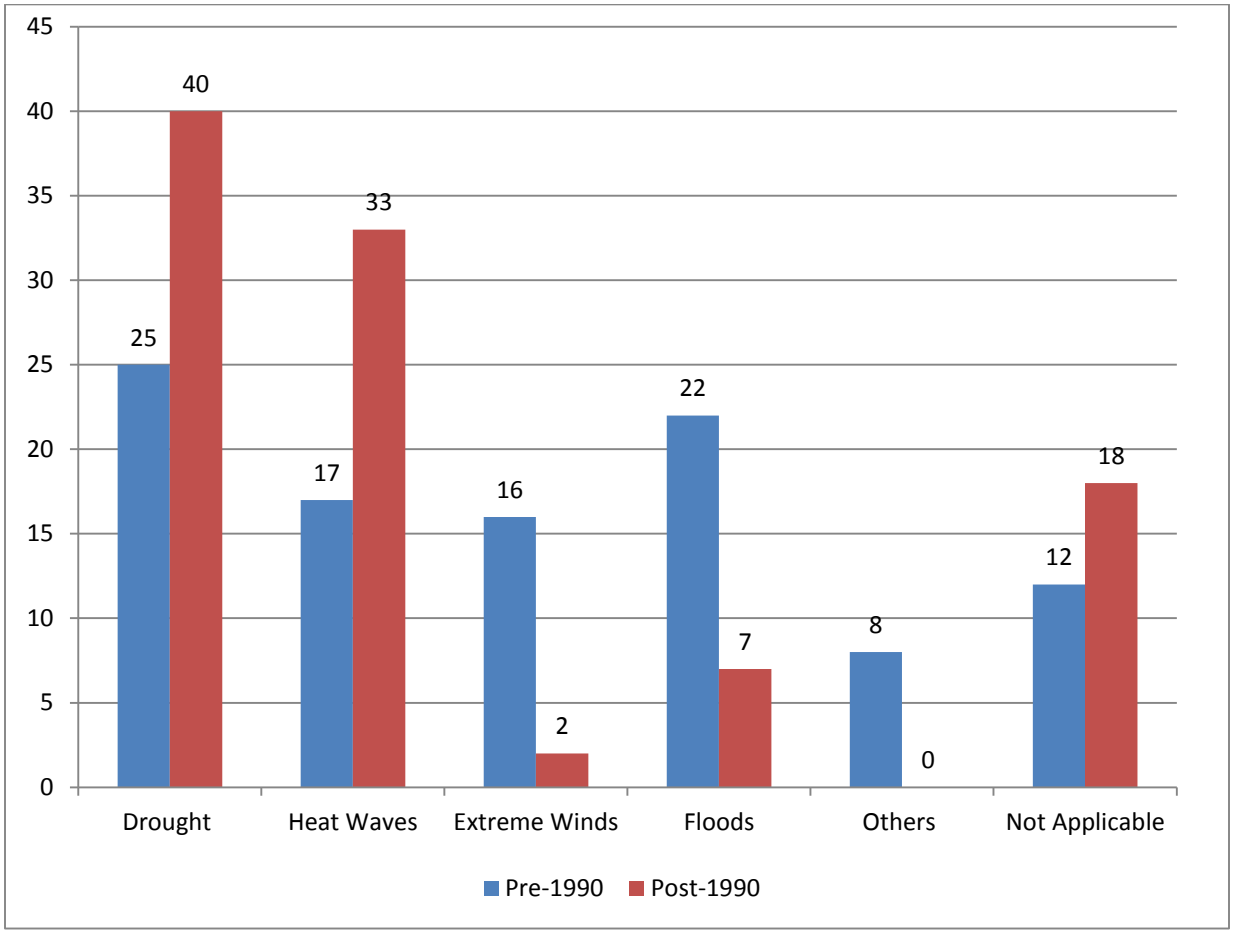
household food availability in rural areas; but, they are also influencing poor harvesting and that has automatically threatened food security and livelihoods in rural areas. Furthermore, only a less significant proportion (14%) of the respondents stated that the climatic conditions were conducive, whereas, a negligible proportion (7%) of the respondents stated that they were not sure if the climatic conditions were conducive or not for livestock rearing. Consequently, a significant proportion (48%) of the respondents stated that they were not practicing livestock rearing in the post-1990 era.

5.19. Climate-Driven Obstacles Faced in Growing Crops in the Pre- and Post-1990 Era

In the pre-1990 era, a less significant proportion (25%) of respondents mentioned that limited episodes of drought were some of the main climate driven obstacles that they faced. Such episodes excluding the one which happened in 1983 had a limited effect on the crop production processes in the 30 villages sampled (Figure 5.16). Similarly, floods were also mentioned by less significant proportion (22%) of respondents as an obstacle that was faced. Moreover, a negligible proportion (17%) of the respondents stated heatwaves. Additionally, negligible percentages of 16% and 8% where those respondents who stated extreme winds and other unspecified climate induced obstacles. Only negligible proportions (12%) of respondents were those who did not produce food in the pre-1990 period. The post-1990 seems to have been the most difficult in the 30 villages in terms of food production. In the sense that, the intensity of

the extreme climatic driven obstacles increased and the levels of crop production declined, particularly among poor households who depended on subsistence farming.

Figure 5.16: Climate-Driven Obstacles Faced by Households in Producing Crops, Pre- and Post-1990



Understandably, a relative significant proportion (40%) respondent mentioned increased extreme and continuous episodes of drought as the major climatic induced obstacle that they faced in the post-1990 era. In this and many other areas, drought had continuously destabilized the poor household's food production, clean water, energy supply, and

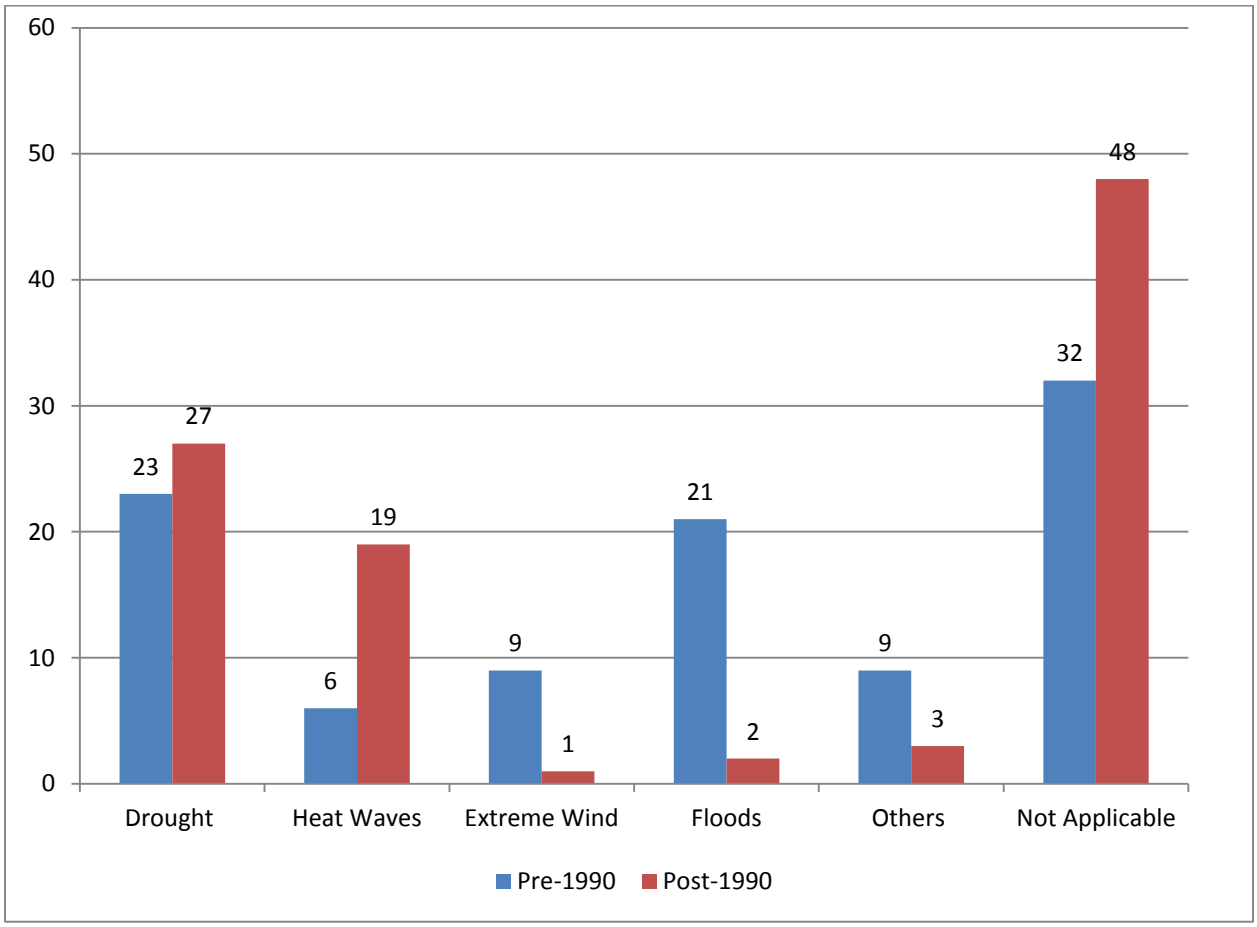
environmental health amongst others in the rural areas (Barnet & Adger, 2007). That is, long periods of excessive hot temperatures without rainfall have destroyed crops in the fields and exposed vulnerability to food insecurity among most households particularly in rural areas such as those in Makhado Local Municipality. Interestingly, a relatively significant proportion (33%) of other respondents mentioned heatwaves as the main climate driven obstacle that they faced. This indication demonstrated how the indicators of climate change such as extreme heat in many parts of the municipality have caused devastating effect on household crop production processes. Negligible percentages of 7% and 2% of the respondents mentioned floods and extreme winds respectively. Furthermore, a negligible proportion (18%) of respondents were those who were no longer producing any crops and have either diversified to income earning livelihoods or were discouraged to continue practicing crop production because of many challenges that were faced.

5.20. Climate-Driven Obstacles Faced in Livestock Rearing in the Pre- and Post-1990 Period

In rural Makhado Local Municipality a less significant proportion (23%) of respondents stated that, in terms of livestock rearing, drought was also a noticeable obstacle in the pre-1990 period (Figure 5.17). As it was already stated in 4.18, such episode of drought did not take long and they had a less significant effect on livestock rearing process. Once more, a less significant proportion (21%) of respondents mentioned floods as the main climate driven obstacle, whereas, a negligible proportion (9%) stated extreme

winds. Only negligible percentages of 6% and 9% of the respondents mentioned heatwaves and other unspecified obstacles respectively. Furthermore, a relatively significant proportion (32%) of the respondents was those who did not rear livestock pre-1990 period.

Figure 5.17: Climate-Driven Obstacles Faced by Households in Livestock Rearing, Pre- and Post-1990



When it comes to the post-1990 era, a less significant proportion (23%) of respondents stated that drought was the greatest climate driven obstacle faced in rural Makhado

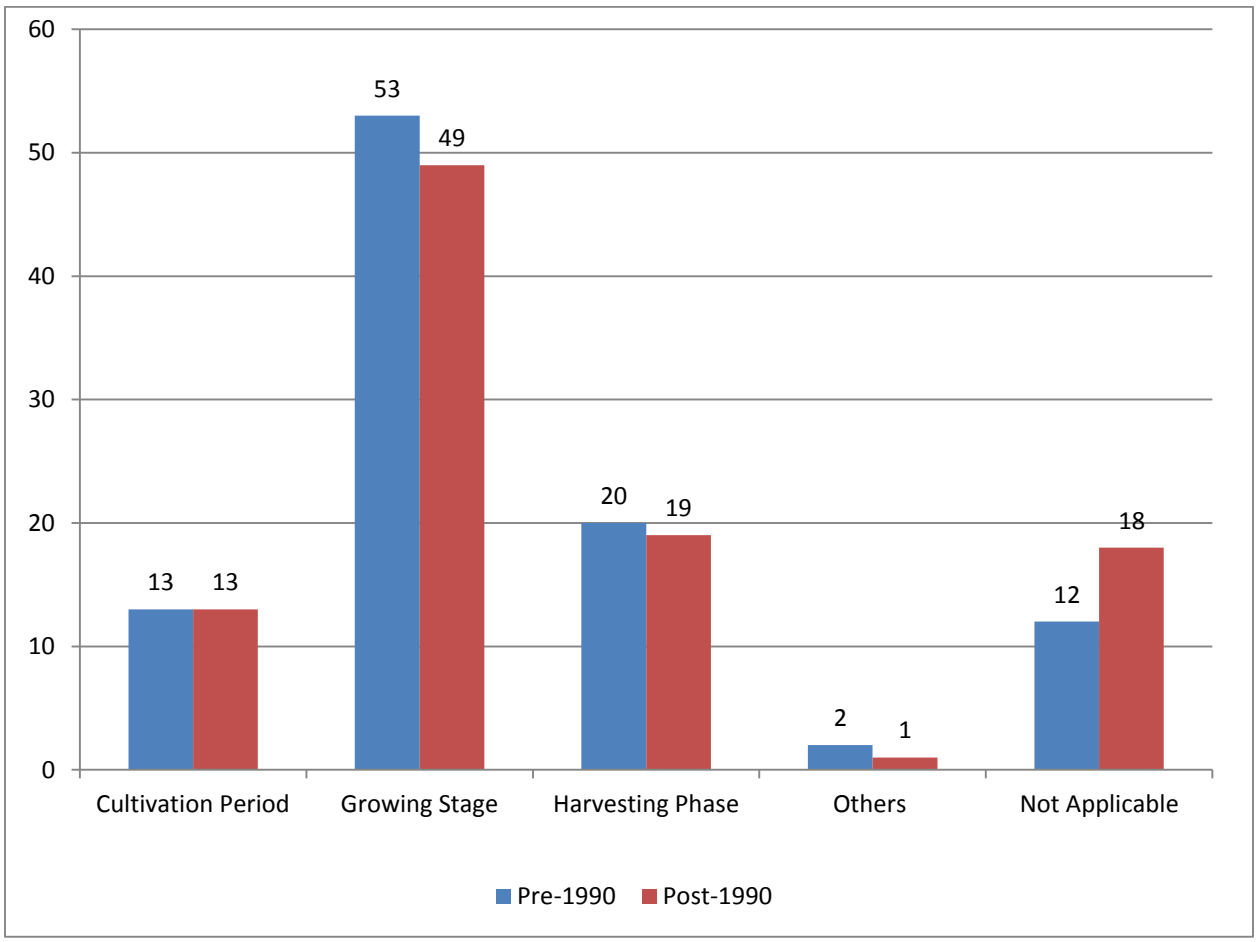
Local Municipality. The long periods of dryness with extreme heat without rainfall was experienced in many parts of the municipality and had a huge effect of livestock. Many livestock died of heat and shortage of grass and water. Similarly, a less significant proportion (19%) of respondents mentioned heatwaves as the main climate driven obstacle they faced. Heatwaves were quoted as having a huge effect on livestock appetite for food and an instigation of different animal diseases. The negligible percentage of 2%, 1% and 3% of the respondents mentioned floods, extreme winds and other unspecified climate driven obstacles respectively. Unfortunately, a relatively significant proportion (48%) of the respondents was those who have abandoned livestock rearing processes due to some of the obstacles mentioned above.

5.21. Crop Production Process Stages and Households Experiences of Climate-Driven Obstacles

In the pre-1990 period, the majority of household respondents (53%) mentioned that they faced some of the climate driven obstacle during the growing stage of the crops. However, the effects of the obstacles were not extreme and the soil conditions were good, thus, the crops were able to survive and produce a successful harvest. For instance, the episodes of drought were short lived and did not cause much damage. A less significant proportion (20%) of the respondents mentioned that they faced climate driven obstacles during the harvest phase of the production and at that time most of the crops were ready to be harvested, thus, the effect was not significant. Additionally, a negligible proportion (13%) of the respondents stated that they faced the obstacle

during the cultivation phase, whereas, a further negligible proportion (2%) of respondents mentioned that they faced the obstacles during different phases of production. A further negligible proportion (12%) of the respondents was not practicing crop production in the pre-1990 period.

Figure 5.18: Stages of Crop Production Process and Households Experiences of Climate-Driven Obstacles



Even though almost the same proportions of respondents stated that they experienced the same kind of obstacles during the same stages of production in the post-1990

period, it was however observable that in the post-1990 era the status of land, limited availability of water and extreme heat has rendered the process of crop production much more difficult. Accordingly, 49% of the respondents stated that the climate driven obstacles they faced were experienced during the growing stages of the crops. Particularly drought and heat waves destroyed a lot of potential crops and left many agricultural fields empty. The low fertility rate on the soil and accelerated evapotranspiration reinforced the extreme effects of these climate driven obstacles. A less significant proportion (19%) of respondents mentioned that they faced the climate driven obstacles during the harvesting phase, whereas, a negligible proportion (13%) of the respondents stated that they faced the obstacles during the cultivation period. Additionally, a negligible proportion (1%) of respondents mentioned other unspecified obstacles, whilst, a less significant proportion (18%) were of those who were no longer practicing any crop production activities in the post-1990 era.

5.22. Intervention and Measures Adopted to Deal with Climate-Driven Obstacles

Due to the extreme challenges of soil infertility majority of households who were still practicing crop production in rural Makhado Local Municipality were applying traditional manures (Appendix C: Photograph 2) to intensify the productivity of the soil. Few households particularly the better-off have established boreholes to extract ground water in order to irrigate the crops especially the ones grown within the homestead yard. The better-off households were also applying pest control mechanism and crop rotation strategies. However, a significant proportion of households were diversifying their

income earning livelihoods in order to get income to buy food. This initiatives confirms the World Bank (2000) assertion which said that, local small-holder and substance farmers adoption of different adaptation measures such as changing crop variety, adopting soil and water conservation measures, harvesting water, planting trees, and changing planting and harvesting periods are apparent to those whose activities are rain dependent amid recent erratic rainfall experiences.

5.23. Conclusion

The socio-economic and environmental conditions of rural Makhado Local Municipality have played a big role in terms of the household's ability to respond positively to the effects of climate change. The devastating effects of drought, heatwaves and sometimes floods, exposed the majority of households whose livelihoods are connected to natural resources such as land for production. Instead of devising coping measures, a large proportion of household have tended to abandon their agriculturally related food production activities and sometimes diversified to other income earning opportunities in order to be able to buy food. However, lack of economic opportunities at the municipal rural areas has rendered majority of households to be food unsecured. The next chapter will provide the findings of the study, conclusions and recommendations.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Introduction

Different aspects of climate change such as drought, heatwaves and floods have caused the greatest effects in many rural areas, particularly of the developing countries. These effects are more visible among poor households whose food production and security activities are intricately bound to agricultural and natural resources. For instance, the post-1990 era has been dominated by long episodes of drought in most of the southern African countries such as Malawi, Mozambique and South Africa. In these countries, the production of crops such maize has been difficult; and, it is predicted that the situation will get worse and lead to a huge decline of food availability which will threaten food security. Consequently, the socio-economic conditions of the majority of rural household dwellers have not rendered adaptation efforts to climate change easy. The levels of poverty in these areas are so high in such a way that strategies to shift resources out of agriculture into other activities that are less vulnerable to climate are unavailable. This situation was confirmed in rural Makhado Local Municipality were a large number of households have abandoned their agricultural food production activities and are relatively vulnerable to food insecurity. The households which are still producing food in this area are both the better-off who have established boreholes to extract ground water for irrigation of crops and those who are applying traditional manure to supplement soil nutrients. Thus, the majority of households in Makhado are no longer able to produce enough food from own production activities in these area. This study

was aimed at investigating the effects of climate change on household food production process in rural Makhado Local Municipality. Some of the objectives to achieve the aim included studying the determinants and indicators of climate change; to examine rural households' food (crops and livestock) production systems; to assess the environmental challenges facing rural households' food production and to uncover the effects of climate change on rural households' food production.

In order to guide the process of making this study a success, different research designs and methodologies were adopted. The study used normative longitudinal and historical research designs in order to evaluate different events and processes associated with the systems and processes of climate change, environmental patterns and challenges to food production and also to assessed changes in crops and livestock that households have produced over time. Desktop review was done in order to evaluate textual data on debates, determinants and manifestations of climate change from international, South African and Limpopo Province perspective and experience. The study collected data through five different data collection techniques, namely literature review, household questionnaire survey, interview schedule, observation and focus group. This was done to solicit different opinions, understandings and experiences about the effects of climate change on household food production in rural Makhado Local Municipality. Furthermore, three levels of data analysis were used to analyse data in a form of description, classification and making connection of different variable under research. SPSS was used to create statistical variations in a form of percentages and frequencies, while MS excel was adopted to create graphs.

6.2. Research Findings of the Study

The study was conducted in rural Makhado Local Municipality in order to investigate, the effects of climate change on household food production processes. The following findings were uncovered in 30 villages which were sampled for data collection:

- From a philosophical perspective, the thesis established that food production systems for self-provisioning have historically constituted the backbone for survival and life-support in rural South Africa. Colonialism and apartheid capitalism bore harsh effects on the food production life-support systems. However, these effects pale into insignificance compared to the present devastation of the food production systems associated with climate change. The contribution of rural South Africa towards climate change is at all scale negligible because poor people hold limited capacity to produce the deleterious gas emissions that allegedly causes global warming. However, the poor are disproportionately exposed to the adversarial effects of climate change and their food production systems have demonstrated beyond doubt that they cannot cope with stressors occasioned by climate change. Government policy and measures continue to be inadequate and inaccessible for rural households that produce for self-provisioning.

- The study found that the discourse of the systems and processes of climate change and its understanding in rural Makhado Local Municipality remain steeped in tradition. Most of the respondents did not understand what could be the cause of the recent lack of precipitation and extreme episodes of drought and

heatwaves. Consequently, some of the household respondents and key informant expressed the historic cultural beliefs and understanding of how they used to call for rainfall through performing rituals of which the majority are no longer practicing. The negligence of this cultural customs is believed to have been the contributor to the recent natural hazards such as drought, unprecedented thunderstorms and unexpected flooding which have destroyed not only crops and livestock but damaged the entire socio-economic network in some of the 30 villages at the municipality.

- Trends of food production activities in rural Makhado Local Municipality have shifted when comparing the situation before and after 1990. A large number of households who were engaging in both crop and livestock production before 1990 were concentrating on either limited crop production activity alone or have abandoned the production process entirely. The levels of livestock rearing have declined drastically at the municipality too. Some of the reasons given for this decline has been lack of enough rainfall for crops and also limited access to grazing sites for livestock. However, the most identified cause of the decline was the extreme hot temperatures which are having a huge effect on crop and livestock growth.

- The study found that households in rural Makhado Local Municipality used to grow different crops and livestock for the purpose of consumption in the pre-1990 period. A bulk of crops such as maize, ground nuts, sorghum, finger millets,

pumpkins, beans, sugarcane and sweet cane were produced; whilst, livestock reared included cattle, goats, sheep, chicken and pigs. However, it was also found that post-1990 era the production declined. In terms of livestock, the most dominant was cattle; however, it is worth mentioning that only few households were still rearing a limited number of cattle with an average of 10 per household.

- There were few main challenges mentioned for both crop production and livestock rearing in the pre-1990 period. The majority of respondents mentioned pest attacks on crops and diseases for livestock as the main challenges they faced respectively. The main issue was that because majority of households in the area did not have access to income, they were not able to purchase pesticides for crops and did not have access to veterinary medication for livestock. However, it was clearly mentioned that such challenges were not significantly affecting the households as they still produced enough crops and reared a large herds of livestock. Diverse of challenges such as drought and heatwaves were identified as the main challenges faced by both crops and livestock rearing in the post-1990 period.

- The study found that the crop and livestock yields that the households produce post-1990 dropped drastically comparing to the situation pre-1990. In pre-1990 households produced enough crops and rear high herds of livestock. For the crops produced, almost all household used to have a number of storage facilities to keep the harvest safe and such enabled the household consume beyond four

seasons of a single year. Furthermore, the livestock reared were many in such a way that some households did not know the exact number of the livestock they had. However, the study found that in the post-1990 era there was a huge decline in production and households were producing limited crops and reared few livestock.

- The study found that in rural Makhado Local Municipality, the environmental and soil conditions were more conducive for crop and livestock production in the pre-1990 period. Households achieved successful harvest of crops without applying any supplements comparing to the situation in post-1990. The environment was also conducive for growth of grassland for livestock feed. However, it was found that because of fluctuating temperatures, the environment was been degraded, grassland areas were dry and river streams were empty in the post-1990 period. These circumstances have caused a huge effect on the lives of households in the area, whose food production activities are only nature based.

- It was also found that in the post-1990 period the majority of households that were still practicing limited food production are doing it at their homestead rather than at the specific agricultural site. Most of the previously assigned agricultural sites were too dry to cultivate and are turned into settlements extensions for residence. Unlike before were households produced in both homestead and agricultural site, only homesteads are used particularly by those better-off households who have boreholes irrigation water and those poor survivalist

households who still try to produce even with limited rain and high temperature experiences. The same case apply to livestock, as it was found that in households which still reared limited number of livestock, such are reared at the homestead. There are very few areas were agricultural sites were still available, particularly for subsistence farming.

- The study found that the temperature and precipitation patterns have changed drastically in the post-1990 period and such were no longer conducive for either household crop production and/or livestock rearing. The consistent rainfall that the villages used to experience before has declined and the warm and cool days are few in a year. There has been an extreme episode of drought and heatwaves in recent times which has affected the food production processes beyond households coping standards.

- The study found that in the post-1990 period in the 30 villages sampled, drought and heatwaves are the main climate driven obstacles which were experienced. The whole climatic system has changed in such a way that episodes of drought and heatwaves are experienced almost every year, which is unlike before were such events were experienced ones in a while. Attesting to the theory discussed in chapter 2, were it was clearly indicated that different areas experiences different indicators of climate change, it was revealed that the experiences of floods were very minimal in rural Makhado Local Municipality as compared to drought and heatwaves. For instance, the only referenced heavy flooding

experienced in the post-1990 period was that of the year 2000 and 2014 which affected a large number of households at the municipality.

- The study found that it has been very difficult for the majority of households to cope with the effects of climate change. The socio-economic conditions of many of households prevented them to devise appropriate climate change coping strategies. However, for some households, adopted climate change adaptation measures included establishment of boreholes for water and diversification of income earning livelihoods in order be able to purchase other food stuffs.

6.3. Recommendations

Guided by the rigorous analysis of the literature, a thorough analysis of the data collected in rural Makhado Local Municipality and research finding as outlined in the previous section. The study propose recommendations as follows:

- The systems and processes of climate change which include its determinants and indicators need to be investigated further in order that a clear global understanding of what constitute climate change, how it affects people and what are its future prospects can be looked at. The fact that there are still a large number of sceptics who doubt the guiding principles of climate change means that the efforts to curb its cause will remain undermined. The complexity surrounding the climate change discourse need to be addressed in order that its

objectives which are strategically connected to those of sustainable development can be achieved.

- Critical evidence on whether gas emissions cause climate change need to be made available. That is, such evidence need to be critically examined and rigorously tested in order that all countries world-wide including different stakeholder and role player on the discourse of climate change can have a clear indication on which strategies need to be put forward in order that gas emissions can be curbed and reduction of the extreme effects of climate change can be realised. The continuous resistance and unwillingness by different countries on the mitigation measures of climate change need to be addressed by presentation of such evidence. Furthermore, clearly outlined financial adaptation measures to support the most affected countries need to be clearly drawn in order that argent intervention can be implemented to those who are already affected and those who are vulnerable to the future effects.

- At the local level, where the effects of climate change are beyond the adaptation capacity of the households, the information about the cause, the effects of climate change and the adaptation measures should constantly be disseminated. This process should be applied in local areas such as those in rural Makhado Local Municipality in order that households can be able to diversify their food production activities and apply different cropping and livestock rearing strategies

which will intensify their food security. One of the main challenges mentioned by the majority of households is lack of water for both crops and livestock. Water provision infrastructure need to be built at the municipality in order that even the poor who do not have boreholes can be able to irrigate some of their crops. However, the provision of water should be accompanied by application of critical measures to rejuvenate the potential of the land for production which is currently degraded beyond the limit.

- Given that drought and heatwaves were mentioned as the main climate induced obstacles experienced, government should intensify its programmes of providing drought resistance seeds and soil supplements in order that the production process of the households can excel during extreme drought conditions. However, in areas where the environmental conditions are damaged beyond repair, government should provide for alternative food production and income earning opportunities which will reduce household's vulnerability to food insecurity and improve the socio-economic status of the majority of community member who live in rural Makhado Local Municipality.

6.4. Conclusion

Climate change is one of the challenges facing the globe today. Its determinants are still debatable; however, its indicators have affected people beyond their imagination. Indicators such as drought, heatwaves and floods have destroyed household's socio-economic networks in such a way that it has exposed them to food insecurity. This is

evident in rural areas particularly of the developing countries where subsistence and small-scale food production are the pillars for household food security. Lack of rainfall and experiences of extreme heat has rendered food production processes impossible in recent times compared to the situation before where food production flourished. Adaptation measure has been difficult to adopt because of the poor socio-economic conditions surrounding this areas. Thus, there is a serious need for government intervention to reinstate the culture of household own food production by providing water infrastructures, soil supplement and drought resistant seeds. However, there is also a need to introduce other food production and income earning activities beyond agriculture in order that households can rely on different food security portfolios.

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APPENDIX A: RESEARCH QUESTIONNAIRE

RESEARCH QUESTIONNAIRE

Doctor of Administration in Development Research Project

Research Project Title: The Effects of Climate Change on Household Food Production in Rural Makhado Local Municipality, Limpopo Province

This questionnaire is meant to gather information on the Effects of Climate Change on Household Food Production in Makhado Local Municipality. This research project is registered with the Department of Development Planning and Management at the University of Limpopo, Turfloop campus. The survey results will be used solely for academic purpose. No information will be used against any member of your household and the community at large. Anonymity of the respondents is guaranteed, and you do not need to write your name on this questionnaire.

Thank you

SECTION A
Demographic Profile of the Household

1) State the number of household members in terms of age and gender categories.

Age	**Males**	**Females**	**Total**
Below 18			
18-30			
31-44			
45 and above			

2) State the number of household members in terms of positions in the household.

Breadwinners	Dependence	Others (specify)

3) State the number of household members in terms of their educational status

No formal education	Primary education	Secondary education	Tertiary education

4) State the number of household members in terms of employment status.

Unemployed	Employed	Self-employed	Pensioners	Learners/Students

5) State and describe the types of livelihoods practiced by the household.
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6) Total monthly income of the household (Tick one with an **X**)

No Income	R1-R500	R501-R1200	R1201-R2500	R2501-R5000	Above R5000

7) What are the Sources of income in the household?

……
……

8) How reliable are the sources of income in the household (Tick with an **X)**

Reliable	Neither /Nor	Unreliable

Explain……..……
……
……
……

9) Identify the nature and type of your household dwellings (shelters) (Tick with an **X)**

Shack	Mud	RDP	Cements/Corrugated	Face Bricks/Tile	Others

10) Identify the sources and use of energy in the household.

Source	**Lighting**	**Heating**	**Cooking**
Electricity			
Paraffin			
Candle			
Gas			
Wood			
Coal			
Animal Dung			
Crop Residual			
Others			

11) Identify sources and use of water in the household.

Source	**Cooking**	**Washing**	**Gardening**	**Others**
Tap in the Household				
Communal Tap				
Rainwater Tank				
Household Borehole				
Community				

Borehole				
Others				

12) Identify type of sanitation facility in the household (Tick one with an **X**)

Sewerage/flush	Pit Latrine	Bush/forest

SECTION B

Household Food Production

1. Identify and describe the types of food production activity(s) that the household practice (Tick one with a **X** and describe under)

Period	Crop Production	Livestock rearing	Both Crop Production and Livestock rearing	None
Pre-1990				
Post-1990				

Describe……
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……
……
……
……

2. Describe the reasons why the household practice such food production activity(s) pre and post 1990.

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……
……
……
……
……

3. List and describe by priority the main crops that the household produced for food pre and post 1990

Pre-1990	Post-1990
1.	1.
2.	2.

3.	3.
4.	4.
5.	5.
6.	6.

Describe……
……
……
……
……
……
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……...

4. List and describe by priority the main livestock the household rear for food pre and post 1990

Pre-1990	Post-1990
1.	1.
2.	2.
3.	3.
4.	4.
5.	5.
6.	6.

Describe……
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5. Identify the main challenges associated with crop production

Period	Floods	Pest attack	Low rainfall	Unfertile soil	drought	Others (Identify)
Pre-1990						
Post-1990						

Explain……..……
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……
……

6. Identify the main challenges associated with livestock rearing

Period	Premature death/Low life span	diseases	Floods	Limited grazing land	drought	Others (Identify)
Pre-1990						
Post-1990						

Explain……..……
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……

7. In which month(s) does the household produce crops?

Type of crops	Month to plough	Month to harvest
1.		
2.		
3.		
4.		
5.		

Explain Why
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……..

8. Do the household have access to crop production technology?

Yes	No

If yes, what kind of technology (Describe)
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……
……
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……
……
……

9. Do the household have access to livestock rearing technology?

Yes	No

If yes, what kind of technology (Describe)
……
……
……
……
……
……
……

10. How much crops does your household produce

Period	Enough	Neither/Nor	Not enough
Pre-1990			
Post-1990			

Explain……
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……
……

11. How much of livestock products does your household produce

Period	Enough	Neither/Nor	Not enough
Pre-1990			
Post-1990			

Explain……..……
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SECTION C

Environmental Conditions in Rural Households

1. Identify the environmental condition of the area where you produce food

Period	Good	Neither/Nor	Bad
Pre-1990			
Post-1990			

Explain……
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……

2. Would you regard this environmental condition as conducive for food production?

Period	Yes	No	Don't know
Pre-1990			
Post-1990			

Explain……
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……

3. Identify the area where the household practice crop production

Period	Home stead site	Specific agricultural land	Other (Specify)
Pre-1990			
Post-1990			

Explain Why

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……

4. Identify the area where the household practice livestock rearing

Period	Home stead site	Specific agricultural land	Other (Specify)
Pre-1990			
Post-1990			

Explain Why

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……
……..

5. Identify the soil condition of the area that you produce food

Period	Fertile	Neither/Nor	Infertile
Pre-1990			
Post-1990			

Explain……
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……
……
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SECTION D

Climate Change and Household Food Production

1. Identify the common temperature patterns of the areas where you practice food production

Period	Hot	Warm	Windy	Cold	Other (Specify)
Pre-1990					
Post-1990					

2. Identify the common precipitation patterns of the areas where you practice food production

Period	Drizzle/Showers	Thunder storms	snow	hail	Other (Specify)
Pre-1990					
Post-1990					

3. Identify the general climatic conditions of the area where you produce food

Period	Wet	dry	Humid	Other (Specify)
Pre-1990				

Post-1990				

4. Do you perceive the climatic conditions to be conducive for crop production

Period	Yes	Neither/Nor	No
Pre-1990			
Post-1990			

Explain

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……
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5. Do you perceive the climatic conditions to be conducive for livestock rearing

Period	Yes	Neither/Nor	No
Pre-1990			
Post-1990			

Explain

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……
……
……
……
……

6. Identify climate driven obstacles that you face practicing crop production

Period	Drought	Heat waves	Wind	Floods	Others (Specify)
Pre-1990					
Post-1990					

7. Identify climate driven obstacles that you face practicing livestock rearing

Period	Drought	Heat waves	Wind	Floods	Others (Specify)
Pre-1990					
Post-1990					

8. How significant would you rate the obstacles that you are facing

Period	Significant	Neither/nor	Insignificant
Pre-1990			
Post-1990			

Explain……
……
……
……

9. At which stage of crop production do you probably experience these obstacles?

Cultivation	Growing stage	Harvesting stage	Other (Specify)

10. What intervention are you adopting to overcome the obstacles that you are face in crop production?

    ……
    ……
    ……
    ……

11. What intervention are you adopting to overcome the obstacles that you are face in livestock rearing?

    ……
    ……
    ……
    ……

Thank you

APPENDIX B: RESEARCH INVERVIEW SCHEDULE

RESEARCH INTERVIEW SCHEDULE

FOR KEY INFORMANTS, GOVERNMENT AND NGO'S OFFICIALS

Doctor of Administration in Development Management Research Project

Research Project Title: The Effects of Climate Change on Household Food Production in Rural Areas of Makhado Local Municipality, Limpopo Province

This interview schedule is designed for probing and soliciting community-wide information from key informants, government and NGO's officials. As a key informants, government and NGO's officials, you are required to provide the community wide information on the households food production processes, types of crops produced, environmental patterns and challenges pre and post 1990, as well as the your understating of the overall effects of climate change on food production. At the most, you could provide us with your stand/position in the community; and your anonymity is guaranteed.

1. Identify and describe the types of food production activity(s) that the households practice in the community pre and post 1990
2. Describe the main crops that the households in the community produced for food pre and post 1990
3. Describe the main livestock the households in the community rear for food pre and post 1990
4. Identify the main challenges faced associated with crop production in the community pre and post 1990
5. Identify the main challenges faced associated with livestock rearing in the community pre and post 1990

6. Do you think households in the community produced enough crops in the period pre and post 1990
7. Do you think households in the community rear enough livestock in the period pre and post 1990
8. Identify the environmental condition of the areas where the community produce food and describe whether such areas are/were conducive for food production in the period pre and post 1990
9. How would you describe temperature, precipitation and general climatic patterns and conditions of the areas where communities produce food pre and post 1990
10. Do you perceive these temperature, precipitation and general climatic patterns and conditions of the area conducive for food production in the period pre and post 1990
11. Describe the major obstacle that the community face producing food in the period pre and post 1990
12. Describe the interventions that the community adopt to overcome the obstacles that they face in the period pre and post 1990

Thank you

APPENDIX C: RESEARCH PHOTOGRAPHS

Photograph 1: Abandoned Dip Tank at Nwaxinyamani Village

Photograph 2: Application of Traditional Manure (Cow Dung) to Supplement Soil Fertility at Hamajiga Village

Photograph 3 : Abandoned Fields which were Previosely Used for Crop Production And Livestock Grazing

Photograph 4: Expansion of Residential Areas into the Previously Agricultural Allocated Land

Photograph 5: Cattle's Looking for Drinking Water in a Communal Tap at Mashau Doli Village

Photograph 6: Cattle's Roaming around Villages Looking for Food

Photograph 7: The Current Outlook of One of the Fading Rivers in Bungeni Village

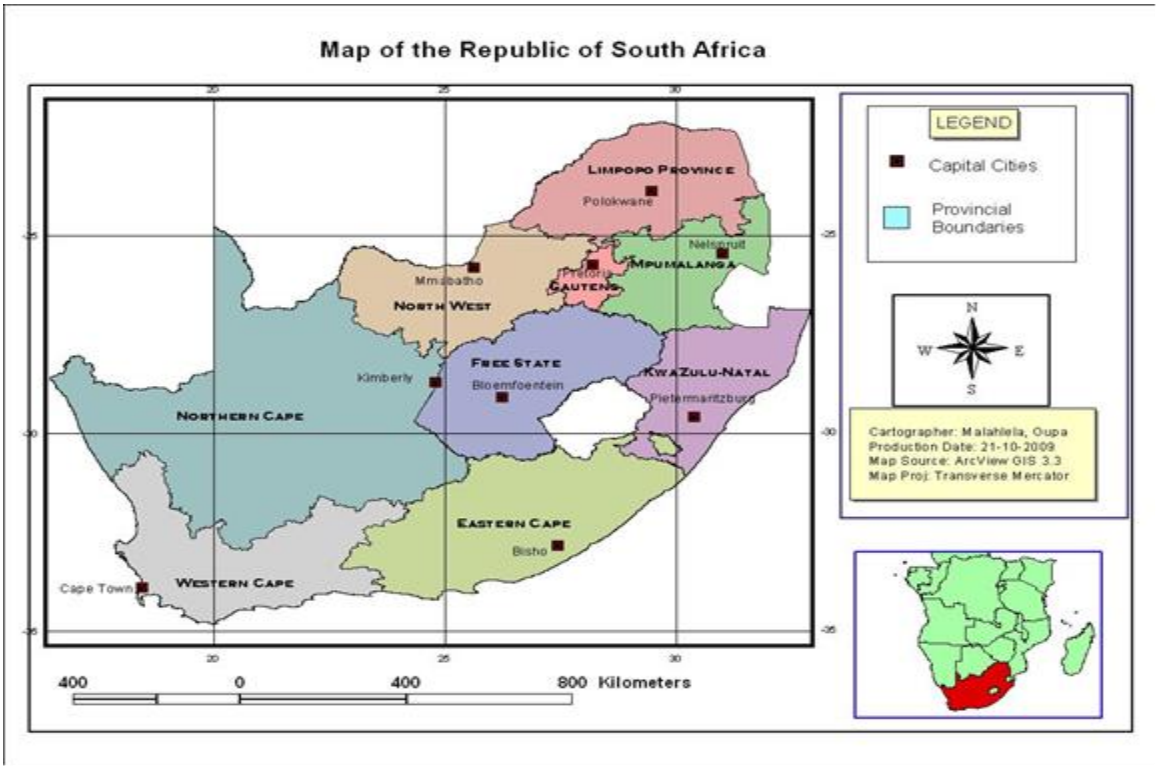
Photograph 8: Connection of Pipes and Sprinkles for Irrigation of Crops and Vegetables

Photograph 9: Irrigated Crops and Vegetable fields in Elim Village

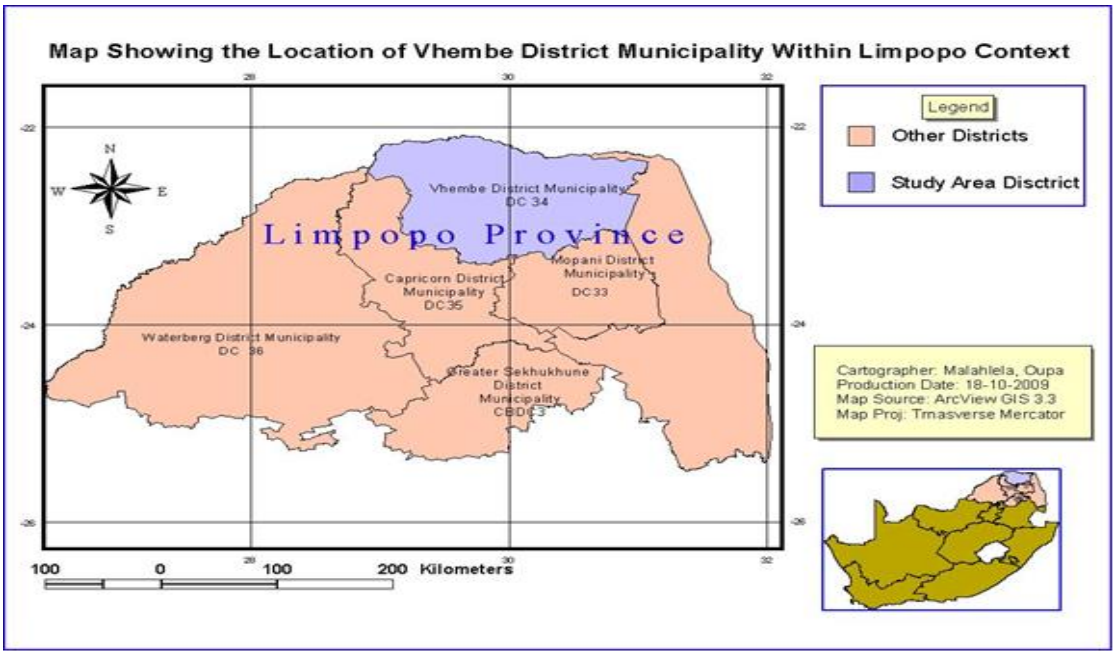
Photograph 10: Water Storage Tanks for Crops and Vegetables Irrigation

APPENDIX D: SOUTH AFRICA, LIMPOPO AND VHEMBE DISTRICT MAPS

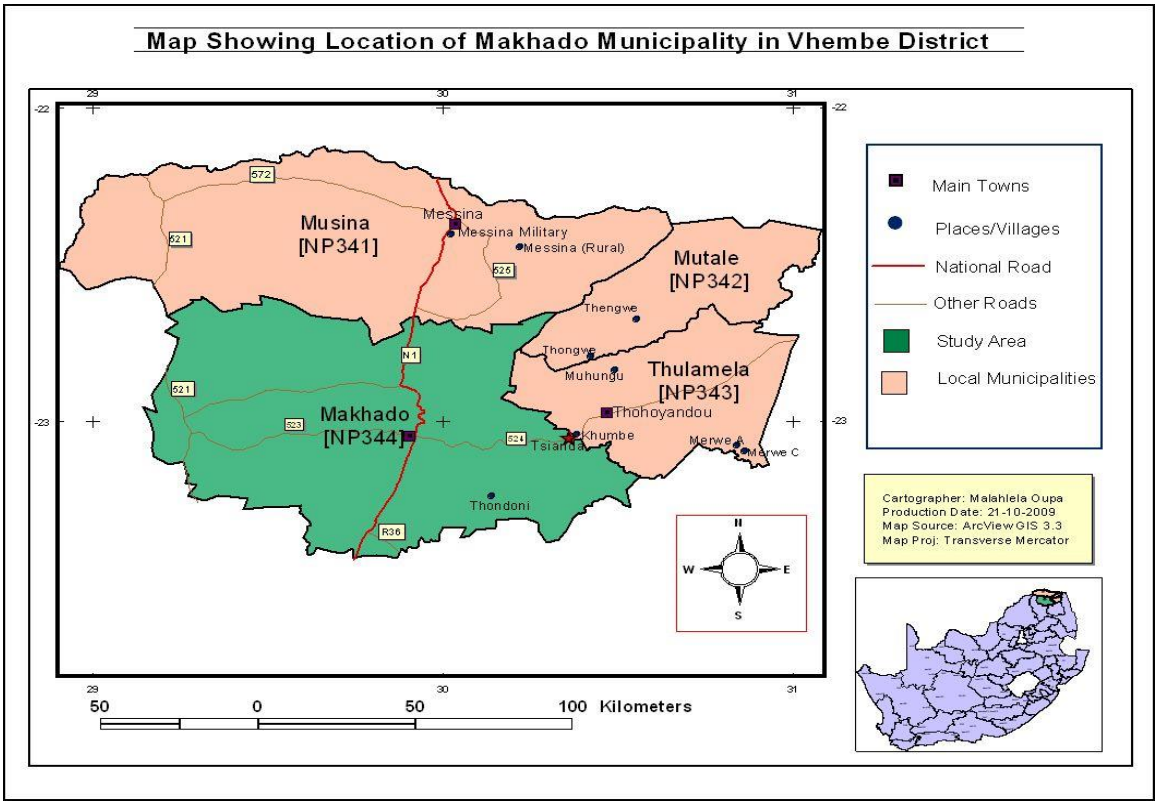
MAP 1: SOUTH AFRICA'S PROVINCIAL MAP



MAP 2: LIMPOPO PROVINCIAL MAP SHOWING DISTRICT MUNICIPALITIES



MAP 3: VHEMBE DISTRICT MAP SHOWING THE LOCATION OF MAKHADO LOCAL MUNICIPALITIES



APPENDIX E: LIST OF SAMPLED VILLAGES FROM MAKHADO MUNICIPALITY

Sampled Villages for Questionnaire Survey	Sampled Villages for Focus Group and Interviews	Sampled Villages for Observation	Total
• Bungeni Village • Tsianda Village • Hamutsha Village • Mashamba Village • Masia Village • Vleifontein Village • Hamajiga Village • Bhokota Village • Rabali Village	• Matsila Village • Tiyani village • Mambedi Village • Mutsetweni Village • Chavani Village • Njhaka-Njhaka Village • Mashau Village • Pfananani Village • Maila Village	• Nwaxinyamani Village • Magoro Village • Mahatlani Village • Waterval Village • Nkuzana Village • Majosi Village • Tshakhuma Village • Valdezia Village • Ha-Masakona Village • Tshirolwe Village • Mauluma Village • Mpheni village	30 Villages