IMPACT OF CLIMATE VARIABILITY ON COFFEE PRODUCTION AND FARMERS COPING AND ADAPTATION STRATEGIES IN HIGHLANDS OF KIGOMA DISTRICT, TANZANIA

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ABSTRACT

Worldwide, climate change and variability have been raising concerns about potential changes to crop yields and production systems. The present study focuses on the effects of climate variability on coffee production among smallholder farmers in highland zone of Kigoma district western part of Tanzania. Specifically, this study aimed at determining how climate variability affects coffee production and the strategies taken by farmers to cope with the problem. Also, this study determined farmers' perceptions about the climate change and variability. Rainfall data and coffee production data for the past thirty years (1981-2010) were used to study the trend relationship between climate change and agricultural production. Data were collected using household survey, interviews, focus group discussion, documentary review and field observation. Sampling unit was the household; a total of 120 respondents were selected from 5 villages. Purposive sampling technique was employed to get the study wards and villages. Two wards were purposively selected and five villages from both wards were selected purposively. In each selected village, 24 households producing coffee were randomly selected from the village register to make a total number of 120 respondents. Correlation analysis was used to examine the relationship of rainfall variability and coffee production in the area while a simple linear regression was used to study the effect of rainfall variability/change on coffee production. Both rainfall and coffee production showed a decreasing trend. The correlation between both trends was insignificant at 5% probability level. Given the weak correlation between rainfall and coffee production and the decreasing trend for both, it can be concluded that, coffee production was not much influenced by rainfall, but there must be other factors like shortage of agricultural inputs such as fertilizers and pesticides which influence coffee production in the study area.

DECLARATION

I, Azizi Mbayu Msuya, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that it has neither been submitted nor concurrently being submitted for a degree award in any other University

______________________ ______________________

Azizi Mbayu Msuya Date

(M.A. Candidate)

The above declaration is confirmed

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Dr. C.P Mahonge Date

(Supervisor)

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LIST OF ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
CIP	Center for International Policy
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organisation
ICO	International Coffee Organisation
IIED	International Institute for Environment and Development
IPCC	International Panel for Climate Change
ITC	International Trade Centre
NAPA	National Adaptation Plan of Action
TACRI	Tanzania Coffee Research Institute
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1Background Information

The first World Climate Change Conference took place in 1979 in Geneva to discuss the real impacts of climate change on agriculture and other development sectors (Koo, 2011). Decision makers from Regional and Federal governments, experts from research institutions and universities, and practitioners from civil society organizations and the private sectors came together for expert presentations and plenary discussions on such impacts. Climate change and variability is already having a significant impact on the agriculture sector which is an important activity in the developing world; as the sector is dominated by rain-fed crop production and households food security is particularly vulnerable to climate variability and change. According to Hulme (1996), rain fed agriculture is an important economic activity in the developing world. Globally, rain fed agriculture is practiced in 80% of the total physical agricultural land on which 62% of the world's staple food is produced (FAOSTAT, 2005; Bhattacharya, 2008).

In recent years, a number of studies conducted in Tanzania have documented that climate change and variability is having a significant impact on agriculture production. According to NAPA (2006), agriculture has been identified to be the second most vulnerable sector to the impacts of climate change, and therefore through a first National Action Plan on Climate Change which contained an inventory of emissions by source and removal by sinks of greenhouse gases helps farmers adapt to new agricultural practices and technologies. Human beings depend for their livelihood on agriculture more than on any other economic activity.

This is particularly true for small farmers in Kigoma District whose economic well-being and food security depends primarily on farming. Kigoma District has been growing coffee as the sole cash crop for more than 20 years.

However, in the last 10 years, the coffee production has faced severe difficulties resulting into low yielding trees. Climate change and variability is said to contribute to such condition. In response to the climate change crisis, farmers have been undertaking various coping mechanism. According to Low (2005), many of the coping mechanisms among the farmers include actions that do not have formal systems recognized by agriculture agencies. The implications of coping and adaptation mechanism may have both negative and positive effects on coffee production. Basing to the above, this study investigated how climate change and variability has been contributing to low coffee production and now farmers have been coping with this challenge in the highlands zone of Kigoma District.

1.2 Problem Statement and Justification for the study

Like many other African countries, the agriculture sector in Tanzania accounts for about half of the national income, three quarter of products exports and provides employment opportunities to about 80% of the population (NAPA, 2006). However, the sector in Tanzania is mostly dependent on rain which makes it vulnerable to climate change and climate variability. This is due to the fact that, climate change affects the two most important agricultural production inputs which are rain and temperature (Deschenes and Greenstone, 2006). A change in rainfall has been considered to affect agriculture production in many parts of the country. Recent analysis of rainfall trends over 20 meteorological stations in Tanzania indicates that, there is a decreasing trend over 13 stations (61.9%) whereas an increasing rainfall trend was observed for 7 stations (33.33%) (New *et al.,* 2006).

Furthermore, an analysis has shown decreasing annual rainfall at an average rate of 2.8 mm per month (3.3%) per decade whereby the greatest annual decreases have occurred in the most southern parts of Tanzania (Mwandosya *et al.,* 1998).

Coffee is a vulnerable crop which needs special climatic conditions if it is to thrive and give a good harvest. Both Robusta and Arabica coffee varieties require agro-ecological areas with hot-wet or hot-temperate climate with frequent rains of about 1000mm or more per annum and temperatures varying between 15º and 25ºC with two months dry spell (Muya, 2008). Arabica coffee which is common in highlands zone of Kigoma District, is more tolerant to low temperatures than the Robusta varieties and can withstand temperatures below 5ºC for some time without damage. However, prolonged temperatures exceeding 30ºC and rains of more or less than required amount are disastrous to both varieties of coffee (Muya, 2008). According to Rosenzweig (1996) heavy rainfall event, excessive soil moisture and flooding disrupt crop production, and temperature rise causes reduced and staggered flowering, different berry growths, and difficulties in timing of operations like disease and pest management, lengthening the harvest and processing seasons and compromising quality. Many studies like climate change and the coffee industry (ITC, 2010), indigenous knowledge in seasonal rainfall prediction in Tanzania (Chang'a*et al.,* 2010) and research protocols for assessing the impact of climate change and variability in Rural Tanzania (Liwenga, *et al.,* 2008) have been carried out over the country to assess the impacts of climate change and variability on agriculture production. However, the studies have done little to address the impacts and the local abilities to adapt to climate variability specifically in Kigoma District. Therefore this study aimed to answer the following questions: what is the trend of climate change? What is the effect of climate variability trend on coffee production? What are the local coping and adaptation mechanisms in response to climate variability? And how can these responses mechanisms be viewed from sustainability point of view?

1.3 Objectives

1.3.1 General objective

The general objective of the study was to assess the impact of climate variability on coffee production and the coping and adaptation strategies under taken by farmers in Kigoma District.

1.3.2 Specific objectives

The specific objectives of the study were to:

i. Assess the trends in rainfall and in coffee production for the last thirty years
ii. Find out the relationship between coffee production trend and rainfall trend for the last thirty years
iii. Assess local community perception on climate variability and change
iv. Examine coffee producing farmers coping and adaptations strategies for reducing risk and vulnerability under climate variability on coffee production

1.4 The study questions

The following were the research questions that were to be answered by this study.

i. What is the rainfall trend for the last thirty years in Kigoma district?
ii. What has been the trend in coffee production for the last thirty years?
iii. How has coffee production in Kigorma District been affected by rainfall variability?
iv. What adaptation/coping strategies have been developed by farmers to mitigate impact of climate variability?

1.5 Conceptual Framework

The conceptual framework (Fig.1) demonstrates a set of relationships among background variables, independent variables and dependent variables. In this context, background and independent variables influence dependent variable. Natural disasters and human activities such as deforestation, emission of gases and agriculture (Background variables) contribute to climate variability and change. However, climate variability and change (independent variable) tend to bring stress such as floods and drought to coffee crop production (dependent variable). Such stresses trigger coping and adaptation strategies which may help a society to adjust to the impacts.

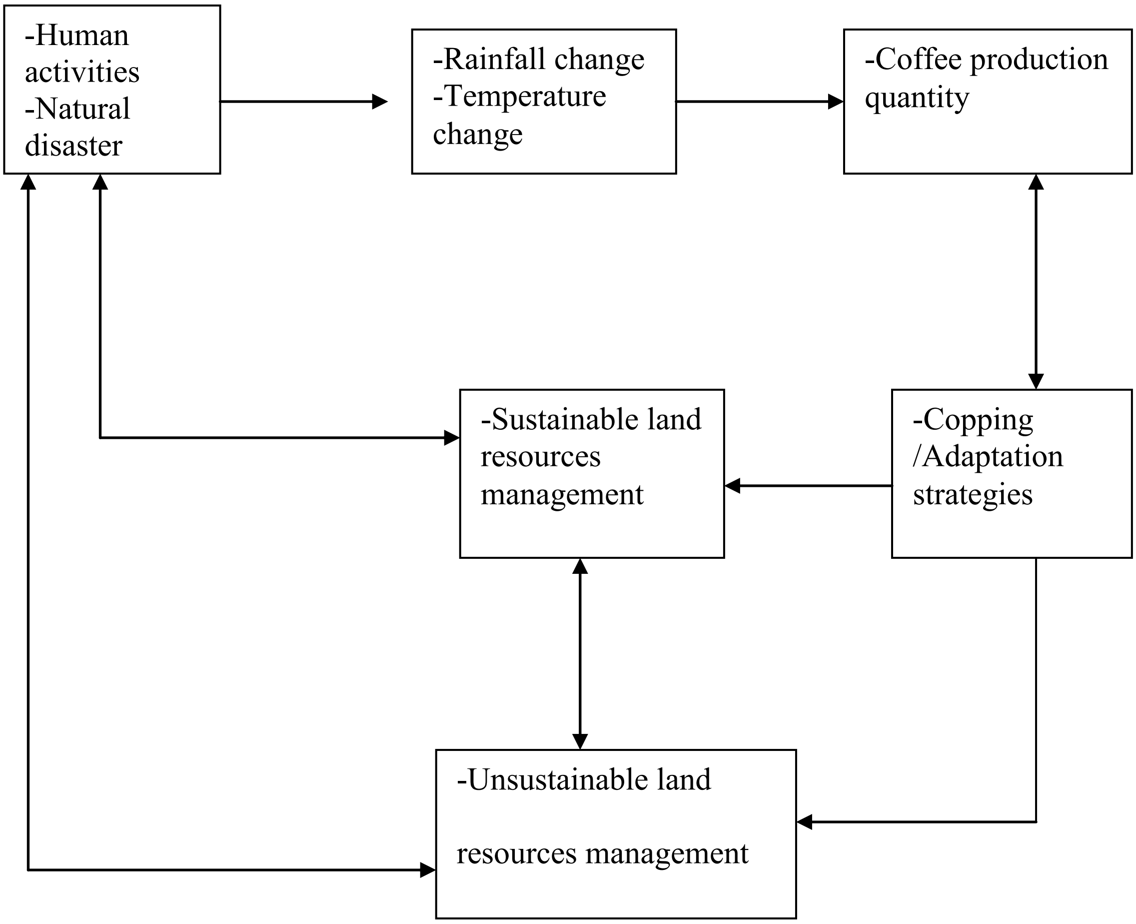


Figure 1: Conceptual framework of the impact of climate change/variability on coffee crop production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of key terms

2.1.1 The concept of climate

Climate encompasses the statistic of temperature, humidity, atmospheric pressure, wind, rainfall atmospheric particles count and other meteorological elements in a given region over the long period of time (Thornthwaite, 1988).

2.1.2 Climate change

However, any statistical significant change of these climatic components over a long period of time from 30 years period to another is regarded as climate change (Pielke, 2004). Wilson (2006) defined climate change as the changes in the average climate over long period of time.

2.1.3 Climate variability

According to hilson (2006), climate variability can be defined as temporary changes in climatic components such as precipitation, temperature, humidity and atmospheric pressure. The IPCC (2007) defines climate variability as the variations in the mean state and other statistics (such as standard deviations, statistics of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events.

2.2 Causes of climate change and variability

Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forces (external variability).

Most of the climate scientists agree that, the current global climate change is due to human activities (Oreskes, 2004). In its fourth assessment report, the (IPCC) Intergovernmental Panel on Climate Change conclude that, more than 90% human activities over the past 250 years have warmed the earth's climate (IPCC, 2007). Human activities through land use change and fossil fuel use have increased the emission of carbon dioxide and other greenhouse gases to the atmosphere (Lean, 2010). This suggests that, the increase in atmospheric carbon dioxide and other greenhouse gases potentially affect climate at regional and global scales. Humans have increased atmospheric carbon dioxide concentration since the Industrial Revolution began and this is the most important long-lived "forcing" of climate change (Cole, 1998).

2.3 The consequence of climate change

The consequences of changing the natural atmospheric greenhouse include warming of the earth whereby some regions may experience warmer temperatures, but others may not, warmer conditions will probably lead to more evaporation and precipitation overall, but individual regions will vary, some becoming wetter and others dryer (Edward *et al.,* 2001). A stronger greenhouse effect will warm the oceans and partially melt glaciers and other ice, increasing sea level. Ocean water also will expand if it warms, contributing further to sea level rise (Schmidt *et al.,* 2004). However, some crops and other plants may respond positively to increased atmospheric carbon dioxide, growing more strongly and using water more efficiently. At the same time, higher temperatures and shifting climate patterns may change the areas where crops grow best and affect the makeup of natural plant communities (Cole, *et al.,* 1998).

2.4 Climate Change and Variability at Global and Regional Level

Humans are influencing climate through increasing greenhouse gas emissions, consequently, changes in climatological patterns have implications or hazards at the global and regional level (Munishi *et al.,* 2006). The major hazards caused by climate change are prolonged heavy rainfall and drought. These hazards could have profound implications for farmers at global and regional level.

An increase in average temperature can lengthen the growing season in regions with relatively cool spring and fall seasons, adversely affecting crops in regions where summer heat already limits production (EPA, 2008). In Africa, extreme natural occurrences such as floods and droughts are becoming increasingly frequent and severe because of climate change and variability (IPCC, 2008). Climate variability and change have further exacerbated the scarcity of natural resources in Africa, this situation led to conflicts with regard to access to, ownership and use of these resources. The scarcity of natural resources is known to cause competition for the insufficient resources available among both individuals and communities, and even institutions, thus affecting human security in the continent (Anthony *et al.,* 2010).

Generally, Climate change affects demand for water through direct physical effects and socio-economic effects such as behavioral changes in water consumption in response to higher temperatures (AfDB, 2000). In most countries, agriculture is by far the largest sector of water use (especially the large irrigators, Egypt, Sudan, and South Africa) climate change and variability will therefore affect these regions due to higher rates of evaporation (Andah *et al.,* 2004).

2.4.1 Climate Change and Variability and Crop Production

Worldwide climatic changes have been raising concerns about potential changes to crop yields and crop production system. This statement is well supported by studies conducted to assess the impact of climate change on agriculture. In its report (IPCC, (2007) concluded that, the increasing atmospheric concentrations of greenhouse gases could lead to regional and global changes in temperature and precipitation. These changes are projected to have impacts on crop production system (IPCC, 2007). According to Schreck and Semazzi (2003) global warming has increased the intensity of heat and reduced the reliability of rainfall in East of Africa thus, causing droughts and floods which have been reported to cause failure and damage to crop production. Similarly, a study conducted by Rosenzweig (2002) revealed that, changes in rainfall patterns and amounts have led to loss of crops in many parts of Africa.

Generally, rainfall and temperature changes are likely to reduce yields of desirable crops. Changes in rainfall patterns may increase the likelihood of crop failures in the short run and decline in production in the long run. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on crop production are expected to be negative (Rosenzweig *et al.,* 2002). Increase in average temperature can lengthen growing season in regions with relatively cool spring and fall; adversely affecting crops in regions where summer heat already limits production (Burke, 2009). In addition, temperature increases lead to higher respiration rates, shorter periods of seed formation and, consequently, lower biomass production (Battisti and Naylor, 2009). Furthermore, higher temperatures result in a shorter grain filling period, smaller and lighter grains and, therefore, lower crop yields and perhaps lower grain quality (Waggoner, 1983). An increase in temperature of below 1ºC may affect transpiration rate up 30% for some plants (Kimball, 1983).

Also temperature increases may cause changes in runoff and groundwater recharge rates, which affect water supplies and changes in capital or technological requirements such as surface water storage and irrigation methods (Oki *et al.,* 2006).

Climate change will more likely lead to a major spatial shift and extension of croplands as it will create a favorable or restricted environment for crop growth across different regions (Olsen and Bindi, 2002). As climate is a primary determinant of agricultural productivity, any significant changes in climate presently and in the future will influence crop productivity.

2.4.2 Climate Change and Variability and Coffee Production

Climate change and variability is threatening coffee production in every major coffee producing region of the world. Higher temperatures, long droughts punctuated by intense rainfall, more resilient pests and plant diseases all of which associated with climate change and in most cases have reduced coffee production (Camargo, 2009). Temperature and rainfall conditions are considered to be important factors in determining growing of coffee. A study conducted by Marengo and Antonio (2009) states that mean temperatures above 23°C hinder the development of coffee and a continuous exposure to daily temperatures as high as 30°C could result in reduced production. Nevertheless, scientific research and participatory assessments show that, many of the current coffee growing regions are already suffering from these changing conditions and are very likely to be affected in the near and long-term future.

In Tanzania, The National Adaptation Plan (2007) quotes a study that estimates the impacts of climate change on coffee production and found that an increase in temperature of 2°C and higher rainfall would increase productivity by 16–18%, but with a 4°C increase in temperature production would become limited in some coffee regions. This situation would have effects on coffee quality, quantity and some times can cause pest and diseases on production.

A quality problem could arise, from the faster plant growth that will lead to lower coffee fruit quality. Besides, high maximum temperatures during summer months may cause an excessive fruit ripening, against fruit quality (TACRI, 2009). Coffee trees are well resistant to high summer temperature and drought, but the increase of extreme conditions can lead to physiological stresses, such as the reduction of photosynthetic efficiency. Other critical phases that may be affected are flowering and grain fill in relation with the anticipation of bud potential break (Muya, 2008). Moreover, high temperature and dry conditions during the reproductive phase can be critical for the optimum coffee production and quality. The setting of adequate air temperature limits for coffee is decisive for the distribution and economic exploitation of the crop. As temperatures rise over the highland areas, coffee yields will be adversely affected. Temperature increases will favor certain pests and diseases, e.g. the coffee berry borer, which currently has little impact over 1500 to 1600m above sea level in many countries (Baker and Hager, 2007). Some diseases and pests that are currently of little importance may achieve greater prominence, especially perhaps in countries that will become wetter (Morales, 2010). On the other hand, greater soil erosion is likely to occur due to increased severity of rainstorms, whereas soils will dry out faster as temperatures increase.

2.4.3 Climate Change and Variability and Smallholder Farmers

Most people depend on agriculture for their livelihood more than on any other economic activity. This is particularly true for small farmers in developing countries whose economic well-being and food security hinges primarily on farming.

Climate change is increasing production risks in many farming systems and reducing the ability of farmers and rural communities to manage these risks on their own (CIP, 2008).

Around the world, farmers and pastoralists are trying to adapt to the effects of climate change, which affect them disproportionately. A study conducted by More (2009) concludes that, climate change mostly affects rural communities, especially those who are living below the poverty line and their livelihoods depend on agriculture. In Sub- Saharan Africa, 93% of cultivated land is rain fed (Hulme, 1996). This puts people living in the area under risk of climate change and variability. This is well proved by studies conducted in Sub-Saharan Africa to assess climate change impacts on the livelihoods of people at macro-level. In East Africa about 40% of the gross national product of countries flows from agriculture, and about 80% of workers are employed in agriculture, most of them on small plots of land (URT, 2010). Climate change and variability adversely affects African farmers particularly those who have no opportunity to use irrigation.

2.5 Adaptation to Climate Change and Variability

Analyses of adaptations in the climate change field emerged along with the growing awareness of climate change itself. An early example is Butzer (1980) who considered ‘‘cultural adaptation’’ (human skill including technological innovation and long-range planning) in light of predicted climate change and its anticipated impacts on world food supply. Since then, analyses of adaptation to changing climatic conditions have been undertaken for a variety of purposes (Kelly and Adger, 2000; Smit *et al.,* 2000). Many social and economic systems including agriculture, forestry, settlements, industry, transportation, human health, and water resource management have evolved to accommodate some deviations from “normal” conditions, but rarely the extremes.

2.5.1 Adaptation to Climate Change and Variability in Agriculture

Efforts to address climate change have so far focused on two response strategies, mitigation and adaptation.

These strategies have been strongly stated in the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Mitigation seeks to reduce greenhouse gases (GHG) emissions to avoid further warming of the globe while adaptation, aims to cope with the problem of climate impacts when they materialize (IPPC, 2001; Huq *et al*, 2006). In agriculture, adaptation efforts focus on implementing measures that help build rural livelihoods that are more resilient to climate variability and disaster. Adaptation in agriculture involves genetic improvement to produce drought tolerant crops, translocation of crops, changes in cropping patterns, forestation, improving water infiltration, providing shade, increasing water use efficiency, diversification into non farm activities, crop insurance and microcredit scheme (Grub *et al*., 1994). Others include cover crops and use of green manure to restore soil fertility especially in the area where leaching occurs due to increased rainfall (Orindi and Muray, 2005).

Adaptation in agriculture also includes improvement of crop management due to the fact that, changes in climatic components lead to changes in production system through shifting of agricultural zones and increased incidence of pests and diseases (Orindi and Murray, 2005). A wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on agriculture. At the level of farms, adjustments may include the introduction of later- maturing crop varieties or species, switching cropping sequences, sowing earlier, adjusting timing of field operations, conserving soil moisture through appropriate tillage methods, and improving irrigation efficiency (Low, 2005). Some options such as switching crop varieties may be inexpensive while others, such as introducing irrigation (especially high-efficiency, water-conserving technologies), involve major investments.

2.5.2 Adaptation strategies to climate variability and coffee production

Adaptation has become an important issue in international and domestic discussions on climate change. Climate change and variability can have a wide range of effects on coffee productivity and farmers must have adaptation strategies to cope with these changes to ensure that production is not only maintained but is increased to support people whose economic depend on agriculture (Smith, 1997). Adaptation strategies may vary considerably among regions, countries and social groups. In many cases, adaptation activities are local at district, regional or national level rather than international (Paavola, 2006). According to Adger (2003) the vulnerabilities of climate change and variability occur at various scales and hence successful adaptation depends on strategies taken at different levels. Therefore in order to adapt to climate change and variability, farmers should have adaptation strategies which may react to climatic variability and change in different forms since some parts of the coffee growing areas have experienced reduced rainfall and high temperature. On the other hand, one of the important characteristic of an adaptation strategy is that, it should reflect the needs and aspirations of the society or community it is meant to benefit. Adaptation efforts must be coordinated across sectors and between agencies, which is a challenge in practice.

Without proper coordination, disparate actions may diminish overall effectiveness (Adger *et al*., 2003). The study by FAO (2007) concluded that a key element in response to both problems is to improve soil organic matter. Soil organic matter stabilizes the soil structure so that the soils absorb higher amounts of water without causing surface run-off, which could results in soil erosion and, or flooding downstream. Soil organic matter also improves the water absorption capacity of the soil during an extended drought.

However, application of good agricultural practices such as shade management, pruning, pest and disease control, soil management and irrigation can be usefully strategies for adapting climate change and variability.

2.6 Coping Strategies

Coping strategies differ based on the area or type of agricultural land, however indigenous people in the world have different coping strategies to respond and adapt to climate change. A study conducted by Sultana (2008) in Bari, exposed the coping strategies undertaken by farmers in the area to cope with climate impacts on crop production, these include cultivation of vegetables and fruits on homestead plots in the coastal areas, planting saline tolerant fruits and timber trees for long term income generation, establishment of community nurseries and distribution of indigenous varieties of tree sampling, switching location (regional or within farm) to new climates or oils and planting deeper in drier conditions, thinning crop in dry years to lower plant density and reduce competition for moisture. However, Oxfam research report (2013) exposed adding of shade in the coffee farm can reduce temperature in the coffee canopy by 2°C. Shade trees or shade crops like bananas have benefit both in long term for farmers as they help to cope the system to increasing temperatures. The coping strategies have helped to maintain household welfare during periods with stress from shocks.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The research was conducted in Kigoma District, in Kigoma Region. The area extends between latitude 05º00S and longitude 30º00E covering land area of 116 55 km² or equivalent to 31.55% of total region land area. It also comprises of a large part of the water area which is 8.029km². Geographically, Kigoma district is located on the southern part of the region, to the north, the district is bordered by Kasulu district, to the East Tabora region, to the South Rukwa region and Lake Tanganyika to the West. Kigoma District has about 105 630 and 160 000 hectares of potential arable and grazing land respectively. Figure 2 show the study area.

The district has more than three important agro-ecological zones, including the highlands zone which lies within an altitude of between 1500 and 1800 meters above the sea level with annual rainfall of 1000-1600 mm. The zone has deep fertile acidic soils but low in Phosphorus and Nitrogen and is suitable for banana, coffee, beans, maize, pineapple, avocado and vegetables. Coffee is the major cash crop of this zone. Most of the people living in the highland zone depend on coffee production for their livelihood. This zone covers a greater part of Mkongoro, Kalinzi, and Mkigo, wards.

The lowland zone lies within an altitude of between 1200 and 1,500 meters above sea level has an annual rainfall of between 850 and 1100 mm. The zone covers much of the east and south of Kigoma District roughly it lies in the area south of the main road Kigoma- Kasulu- Kibondo. The zone is rather an extension of the western plateau and is below the high land zone. Common food crops grown in the area includs maize, sorghum, millet, cassava and beans while oil palm and cotton constitute the main cash crops.

The Lake Zone has an altitude of about 1200 meters above the sea level with an annual rainfall fluctuating between 600 and 1000 mm. The Lake zone forms a narrow strip of land and lies between the lake and the mountains. Crops grown in this zone includes, cassava, maize, beans and oil palm. However, the main economic activity is fishing. Population is sparsely distributed with more concentration on the shores of the lake.

According to the National census (2012), there were about 427 024 people in Kigoma district, the population density was 42.4 (rural) and 1127.0 (urban) persons per square kilometers. There are various ethnic groups in the district including Goma, Bwari, Waha, Tongwe, and Hangaza. Others are Manyema, Bemba and Nyakaramba. The majority of the residents depend on agriculture for their livelihood. However, few people engaged in other activities like fishing, beekeeping and lumbering.

Kigoma District experiences a diversity of climatic conditions. Annual rainfall ranges between 600 mm and 1600 mm, mostly distributed along and around the Lake and in the highlands zone. Most rainfall (rainy season) is seen in January, February, March, April, November and December.

The pattern of rainfall is unimodal with the rainy season lasting from October to May with short dry spell of 2-3 weeks in January or February followed by a prolonged dry season. Precipitation is reliable and allows a wide range of crops to be grown with some double planting of short season crops.

Lowland areas are warm for most part of the year. Mean daily temperature ranges between 25ºC in December and January to 28ºC in September. Temperature varies inversely with altitude. Lowland zone tends to be warmer than the highlands zone.

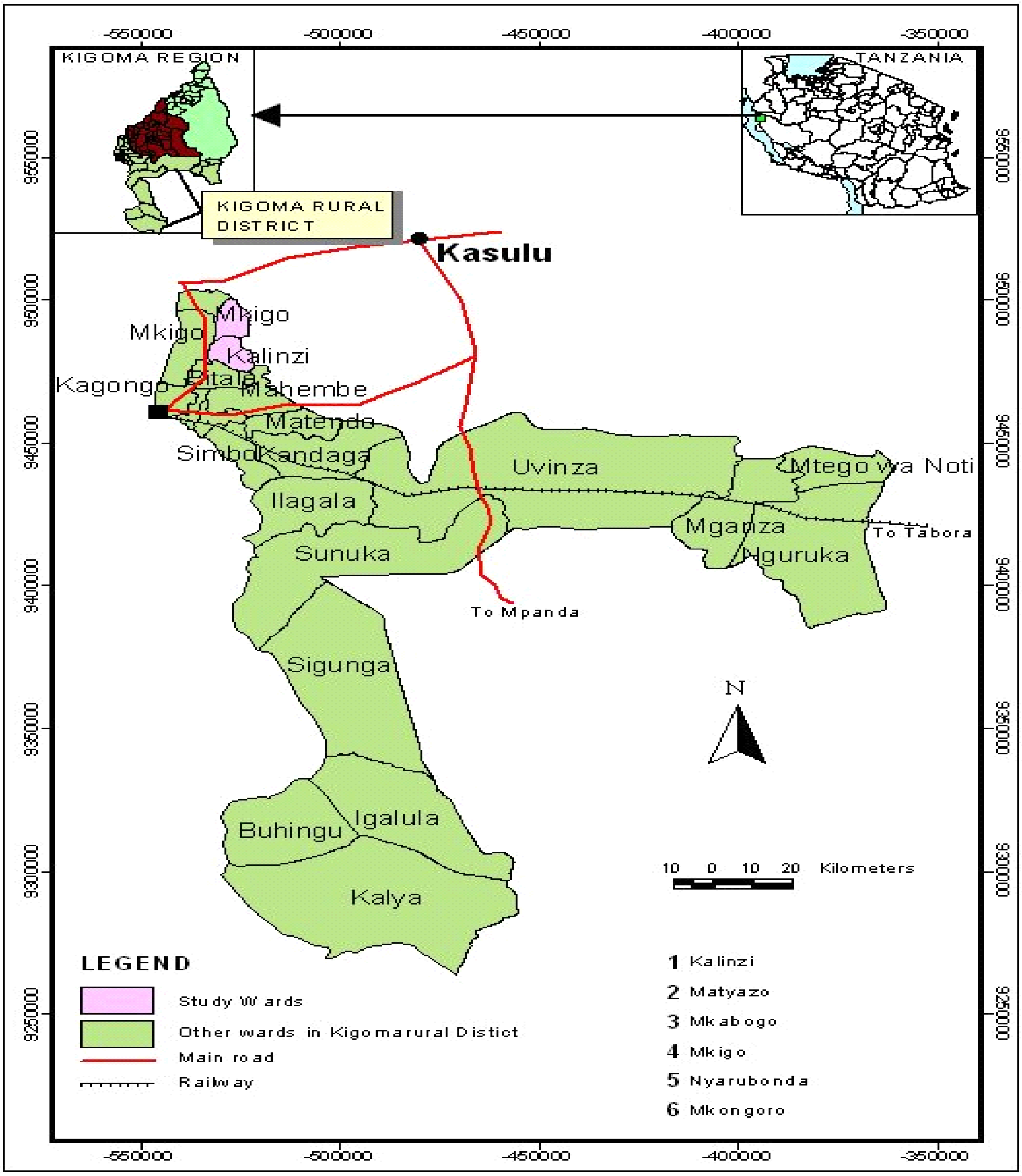


Figure 2: Map showing the study area, Kigoma District

3.2 Research Design

The study used a cross sectional design, the design allows in depth data collection from different groups of respondents at one point at time (Bailey, 1998). The study targeted farmers who grow coffee in the highland zone of Kigoma District. The sampling unit was the household whereby a total of 120 respondents were then selected from 5 villages. Purposive sampling technique was employed to get the study wards and villages as it is known that not all wards producing coffee. Two wards and five villages from both wards were purposively selected. In each selected village, 24 households producing coffee were randomly selected from the village register to make a total number of 120 respondents.

3.2.1 Preliminary visits

Reconnaissance survey was conducted so as to familiarize with the research site and gather the general information. The main purpose of preliminary visits was to introduce the researcher and the research to the community. Normally, it takes a long time for the communities to become comfortable with strangers. At first they may be unwilling to answer questions as they are doubtful. Doubtfulness will decrease with time as the communities become familiar with the researcher.

3.2.2 Data collection methods

In collecting the primary data for this study, household survey and interview methods were used; documentary method was used for collecting secondary data. The study collected both quantitative and qualitative data. In gathering Socio-economic data, semi-structured questionnaires with both open-ended and close-ended questions were used to get information from the households. Also individual interviews were carried out to get information from the farmers within the targeted households.

Questions that capture the trends in coffee crop production and climate change and variability were used to identify changes over time and farmers perceptions on these changes. Questionnaires were also administered to farmers to get information on coping and adaptation strategies to climate variability and change (Appendix 1). In addition, a checklist of questions was administered to key informants. On the other hand, secondary data on coffee production, rainfall and temperature for a period of 30 years (1981-2010) were collected from district agriculture office, metrological stations and district water engineer through documentary review method. These methods intended to collect information on the effects of climate variability on coffee production and farmers coping strategies.

3.2.3 Data analysis

Data from the respondents were verified, compiled, coded and summarized and analyzed using the Statistical package for social science (SPSS) and excel computer programs. The findings were then presented using frequencies, tables and graphs. Descriptive statistics including frequency distribution were computed. In addition cross tabulation done to make comparison. Rainfall and coffee production data for the past 30 years were analyzed for trends and correlation. Furthermore, data collected from checklists and researcher's diary were analysed using content analysis technique which mainly involved transcription of information recorded in the notebooks and then clustering information into sub-themes.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discusses the major findings of the study. The first part gives the findings on socio- economic characteristics of the sample population including age, sex, marital status, education and occupation. The second part presents the trends in rainfall and coffee production, the third part describes the relationship between rainfall trend and coffee production trend while the fourth part provides the information on local community perception on climate variability, their coping and adaptation strategies in the highland zone of Kigoma district.

4.1 Socio economic Characteristics of the Coffee Farmers involved in the study

The socio-economic characteristics such as age, sex, family size, marital status and education are critical to farm decisions and performance in relation to climate change and variability. Respondents' level of education helps them to understand the general farms requirements and its application at the right weather season while age reflects farming experience. Sex and marital status determine responsibilities for male and female farmers in the whole process of crop production. In addition, family size gives good determination of labour force on production. Table 1 shows the socio-economic characteristics of the sample population in the study area whereby less than 60% of the household heads had the age between 50 and 60 years, 35% between 61 and 70 years, 3% between 71 and 80 years while 2% had the age above 80 years. About 75% of the respondents are inhabitants of the area and 25% are migrants from other areas particularly from neighboring countries of Rwanda and Burundi. About 90% of the sample populations have been the residents of the area for more than 30 years.

This shows that the sampled populations are well familiar with the study area. On the other hand, the heads of the households were male in 80% of the studied households while 20% of the households were headed by female. As far as marital status is concerned, 92% of the respondents were married whereas few respondents (6%) were either widows or divorced.

Regarding education, about 90% of the respondents had primary school education while a small number (10%) had either secondary education or had no formal education at all. In terms of household size, the majority of the households in the sample population had an average of 6-8 members.

Table 1: Socio economic characteristics of the respondents (n=120) in the highland zone of Kigoma District, Tanzania

Socio economic characteristic	Frequences	% of response
Age		
Respondents between 50 and 60	72	60
Respondents between 61 and 70	42	35
Respondents between 71 and 80	04	3
Respondents above 80	02	2
Sex		
Male	96	80
Female	24	20
Marital status		
Married	111	92
Single	02	2
Widowed	05	4
Divorced	02	2
Level of education		
Primary school education	108	90
Secondary school education	02	2
Non formal education	10	8
Economic activities		
Coffee crop production	72	60
Both coffee crop and livestock production	42	35
Business	06	5

4.2 Trends in Coffee Production

Based on several documents from the District agricultural office and one report of Rumako Cooperative Union which collects and sells all the coffee from Kigoma region, coffee production has shown a decreasing trend over the thirty years period (1981-2010). According to the data, maximum total annual coffee production in the area was 736 tons in 1982 followed by 687 tons in 1985 and 683 tons in 1988 and has since then fallen considerably except a few years when there was improvement in production. Regardless of increase in area under coffee crop, production has been decreasing over the same period. Fig. 3 illustrates the decline of coffee production in the highland zone of Kigoma District.

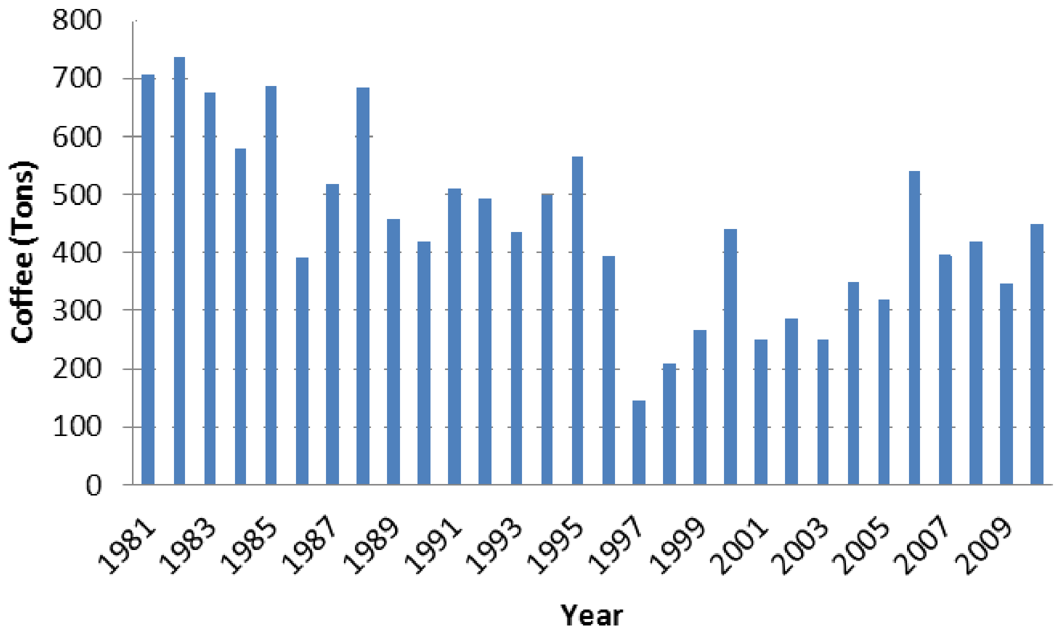


Figure 3: Coffee production trend in the highland zone of Kigoma district (1981-2010

The average annual coffee production in the district for the range of five years showed a decreasing trend, for example average annual coffee production for 1981 to 1985 was 676.8 tons while average annual coffee production for 1986 to 1990 was 493.8 tons.

As such, the productivity of coffee in the area declined for an average of 183 tons from 1981 to 1990. Results from the data are closely similar to farmers' perceptions on production trend. When farmers were asked about production trend, the majority (91%) revealed that production has been in a declining trend over the thirty years period. While the average production for the period between 1991 and 1995 was 500.8 tons, the average production realized between 1996 and 2000 was 291.4 tons whereas average production for the last 10 years from 2001 to 2010 indicated an increase at non significant rate of 139.6 tons. International coffee organization report (ICO, 2006) showed that, production of coffee in Africa has decreased from 1,126.5 to 869.6 thousand tons yearly. Taking the countries that are members of the international coffee organization, the production has decreased in 16 countries but has increased in 9 countries. Coffee production trend in Kigoma is in agreement with ICO report which shows a declining trend in Africa countries.

Three quarters of the number of farmers interviewed in the study area (75%) associated the declining coffee production with non-climatic factors such as absence of agricultural inputs and inadequate extension services. Their views closely agree with result obtained through correlation analysis of rainfall variability and coffee production in the study area. When assessing coffee production trend in Kigoma district from 1981 to 2010 it appears that, in the early years (1981-1995) production was good compared to the succeeding years from 1996.

4.3 Trends in Rainfall

Rainy season in Kigoma is from October to May. A dry period occurs from June to September. On average, the warmest month is August and the coolest month is November. March is the wettest month and July is the driest month.

The results of meteorological data for rainfall during the rainy season from October to May showed a declining trend for the last 30 years from 1981 to 2010. Trend analysis of rainfall data (Fig.4) indicates small variation in inter-annual rainfall. Regardless of small variations in inter-annual rainfall, overall rainfall amount was found to decrease over the years. Geographically, the area has an altitude of between 1500 and 1700 mm above sea level with characteristics of total annual rainfall ranging from 1000-1600 mm. Over the thirty years period (1981-2010) the lowest rainfall recorded in the area occurred in 2005 with an amount of 742 mm while the highest rainfall recorded within the period was 1173 mm in 1982. However, Data showed that, within the time (1981-2010) only eleven years experienced annual rainfall of more than 1000 mm, while nineteen years experienced rainfall less than 1000 mm. This illustrates the fact that rainfall is less in the area.

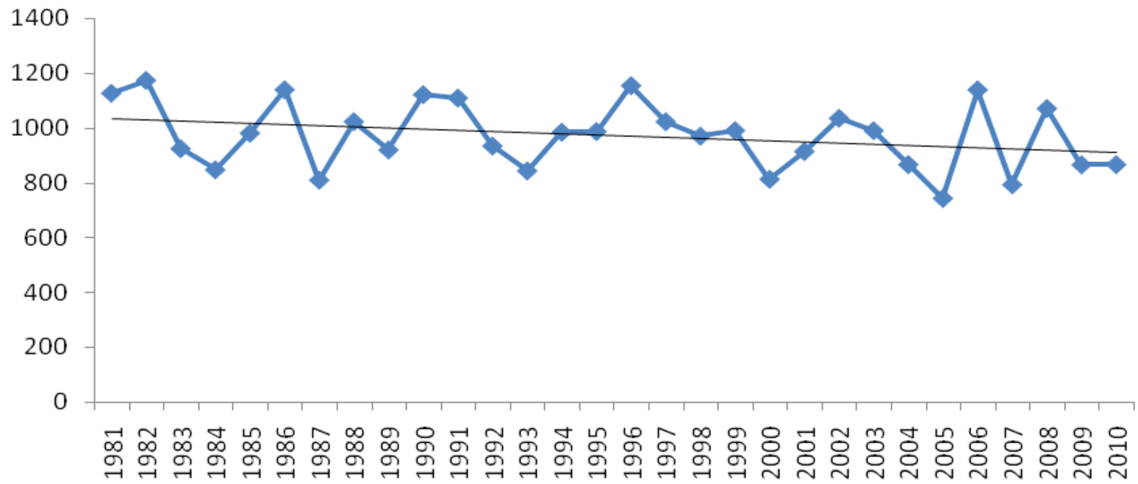


Figure 4: Annual rainfall trend in Kigoma district (1981-2010).

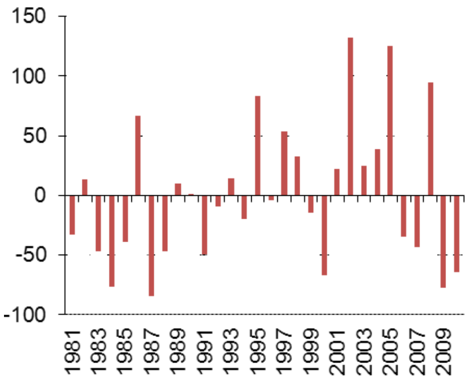
Also outside the traditional rain season, rainfall occurred in June 1995 and July 1998 by a rate that was highly significant though traditionally these months fall under the dry season. This suggested a splitting of the season into short and long rains. However, the total amount of rainfall at the onset of rain season recorded in October in the decade 1981-1995 was 1451.8 mm, while for 1995-2010 the rainfall was 1005.3 mm.

Based on the data, possibly the number of rain days showed a decreasing trend from one year to another. Starting 1990s, there have been noticeable changes in the onset of rains which have tended to be delayed, short duration of rainfall period associated with heavy storms. Also at the onset of rain in October 1997 rainfall amount recorded was too high compared to October of other rain seasons over the period of thirty years. This was also reflected in local people's perceptions; they mentioned the extreme event of flood to have occurred in 1997. This was a clear shift in weather patterns that can be attributed to climate variability. Anomalies graphs (Fig.5) indicate variability of rainfall over thirty years from January to December (1981-2010).

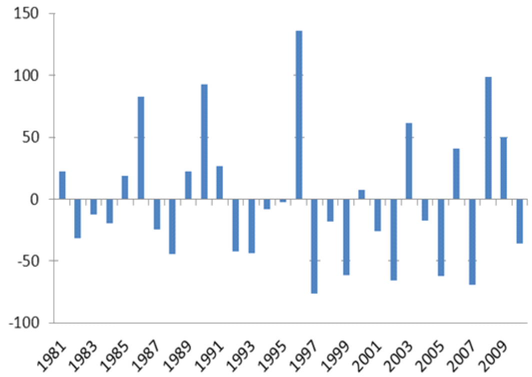
In the same way, analysis of rainfall trends for 20 meteorological stations in Kigoma District indicates that, there is a decreasing trend for 13 stations (61.9%) and an increasing rainfall trend is for 7 stations (33.33%) (Mwandosya, 1998). In addition, analysis shows that areas in Tanzania with a bimodal rainfall pattern will experience decreased rainfall of 5% - 45% and those with unimodal rainfall pattern will experience decreased rainfall of 5% - 15% (Munish*et al.,* 2006). Decline of rainfall trend in the study area is also supported by the IPCC report (2007) which forecasted increasing warming in most part of western Tanzania. In the same manner, the International Institute for Environment and Development (IIED) forecast a rise in temperature of between 2 and 4ºC and decline in rainfall over western Tanzania (IIED, 2009).

When asked about their views on rainfall trend, most of farmers (95%) perceived an increase in temperature and rainfall change. This illustrates the fact that drought is common in the area. Further data verify that, over the period of thirty years (1981-2010) the last fifteen years from 1995 to 2010 received minimum rainfall amount that was not experienced for the first fifteen years from 1981 to 1995.

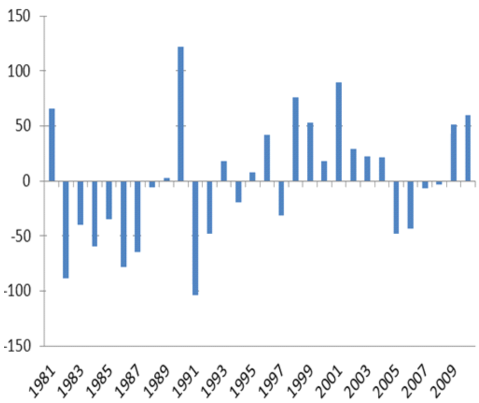
January



February



March



April

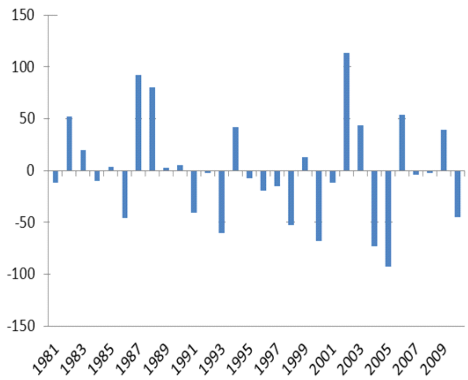


Figure 5: Anomalies graphs for rain in Kigoma District (1981- 201

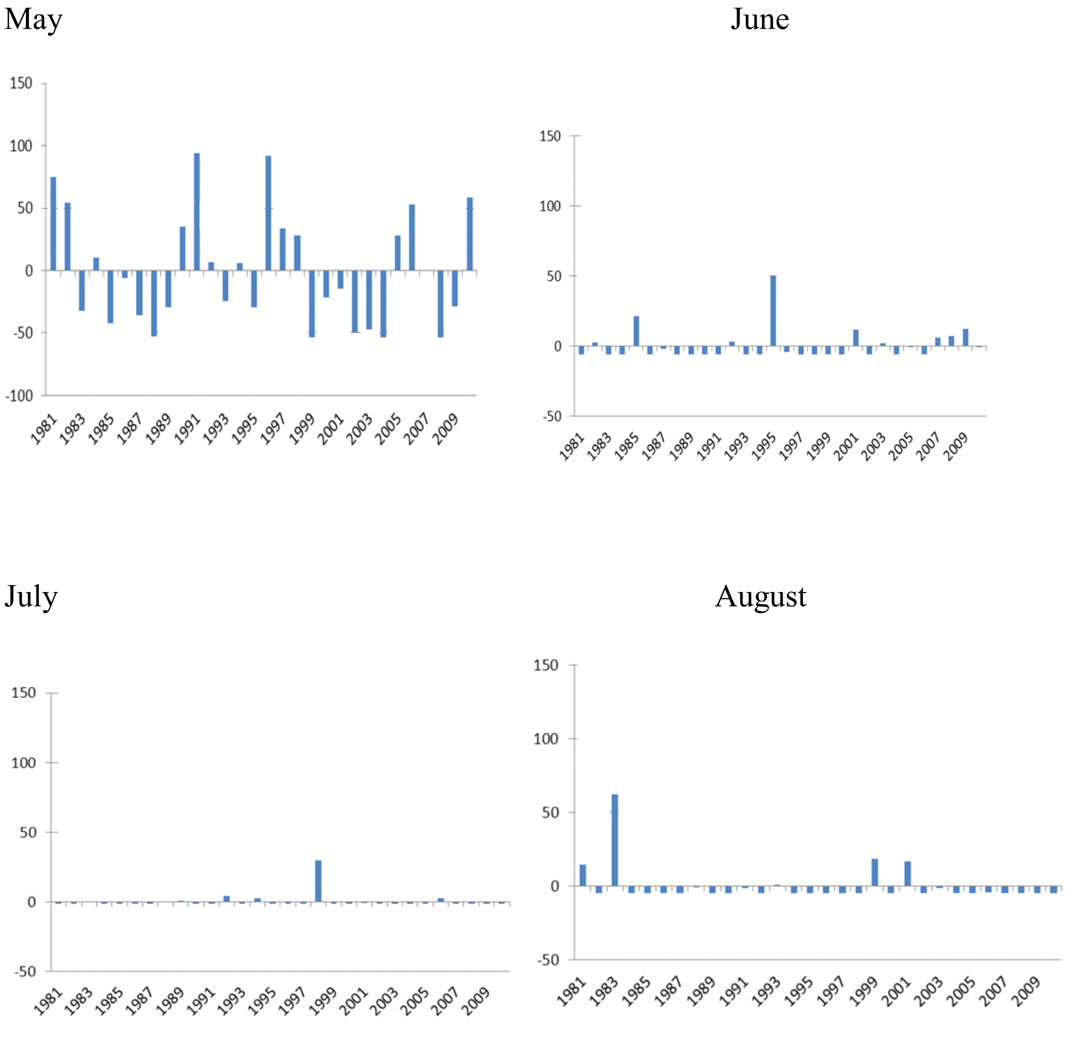


Figure 6: Anomalies graphs for rain in Kigoma District (1981- 2010)

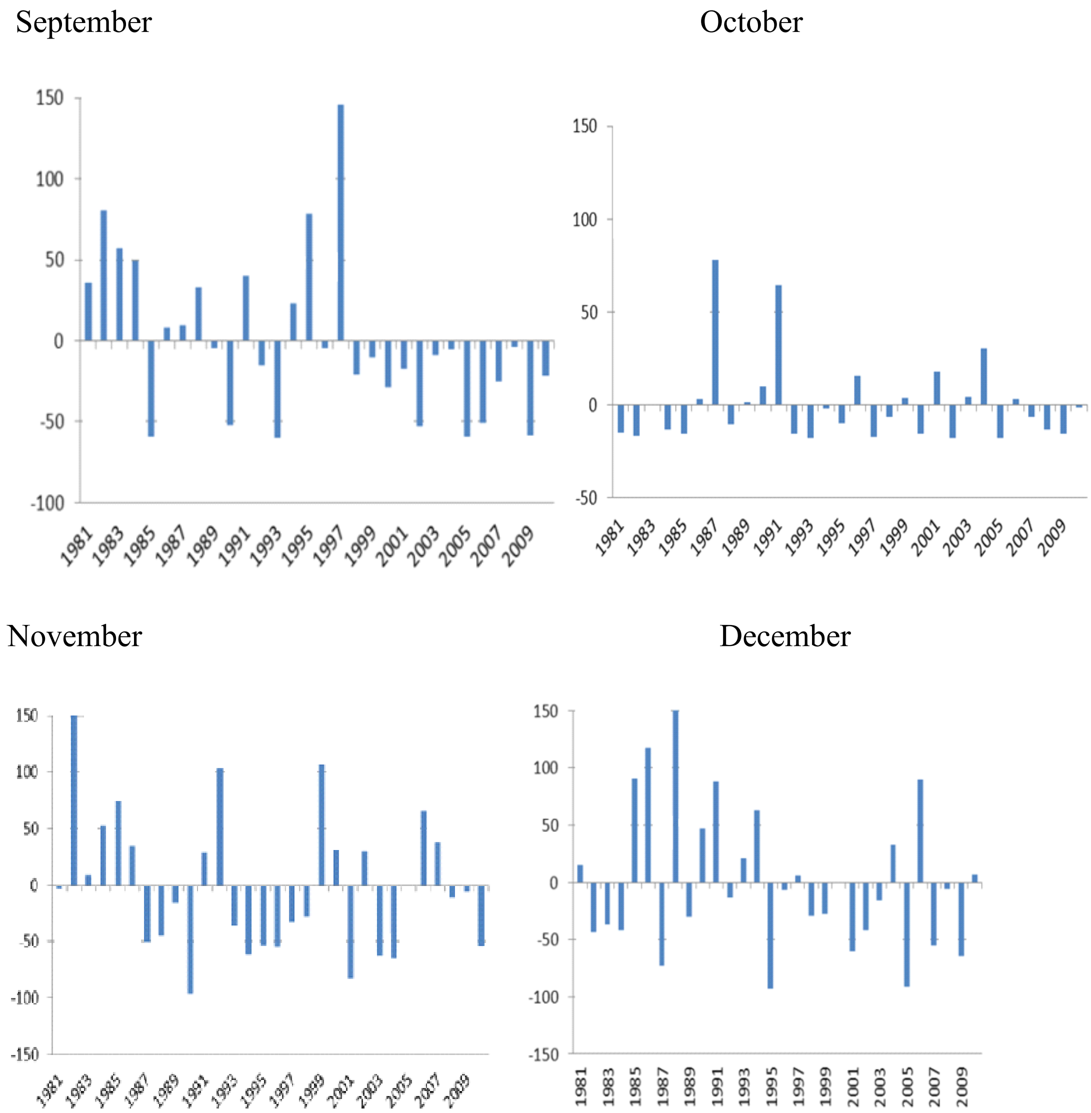


Figure 7: Anomalies graphs for rain in Kigoma District (1981- 2010)

4.4 Relationship between Rainfall and Coffee Production

Numerical data for rainfall collected at the meteorological stations were tested against coffee production data collected from District agricultural office. Correlation analysis was used to examine the relationship of rainfall variability and coffee production in the area while a simple linear regression was used to study the effect of the independent variable (amount of rainfall in millimeter) on the dependent variable (amount of coffee in tons). Statistically, analysis showed that there was a weak relationship between amounts of coffee in tons produced and amount of rainfall in millimeters from 1981 to 2010. The scatter plot (Fig. 6) elaborates more on the relationship between the two variables.

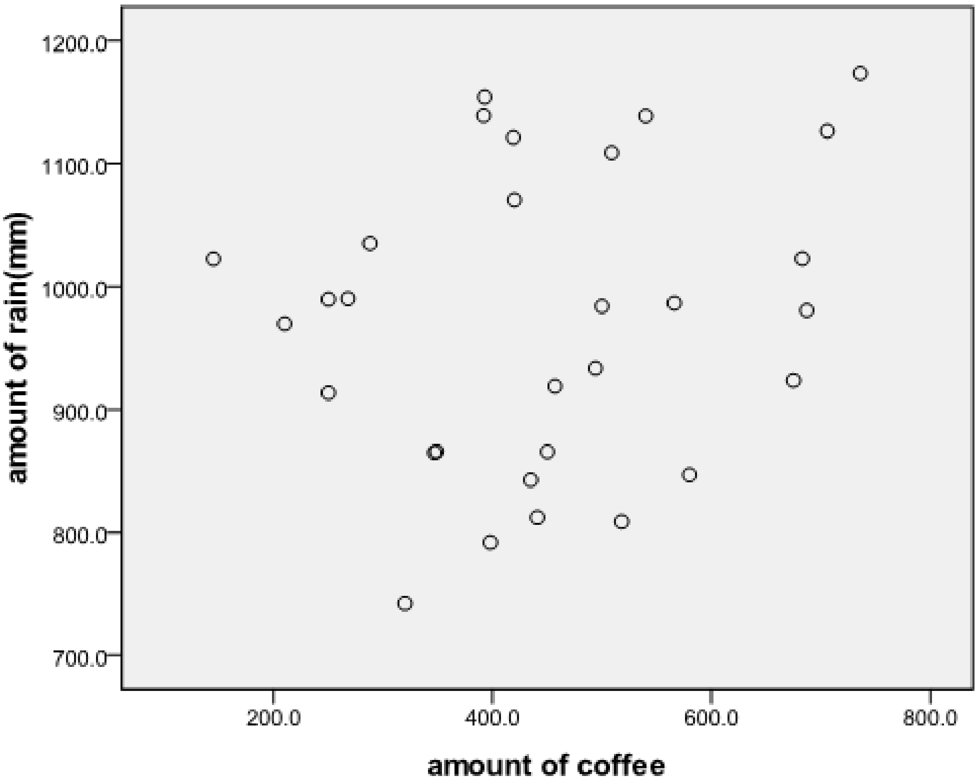


Figure 8: Scatter plot demonstrating the amount of coffee in tons versus the amount of rainfall in millimeters

The relationship between the amount of coffee in tons produced and amount of rainfall in millimeter was statistically insignificant at 5% level (p = 0.275). This indicates that coffee production was not much influenced by rainfall, but there must be other factors like shortage of agricultural inputs such as fertilizers and pesticides which influence coffee production in the study area.

Table 2 depicts the results of the correlation analysis between amount of coffee in tons and amount of rainfall in millimeter.

Table 2 : Correlation Analysis between amount of coffee in tons and amount of rainfall in millimeters

		Amount of coffee	Amount of rain
Amount of coffee (tons)	Pearson correlation	1	.206
	significant (2- tailed)		.275
	N	30	

On the other hand, simple linear regression model was used to see the effect of independent variable (amount of rainfall in millimeter) to dependent variable (amount of coffee in tons). The regression analysis result shows that only 4.2 per cent of total variations in the coffee production can be explained by the amount of the rainfall where by other 95.8% per cent can be explained by using other factors. This means that, the amount of rainfall has less impact on the amount of coffee produced (Table 3).

Table 3: The relationship between climate variability and coffee production in Kigoma district – Regression analysis

	Unstandardized Coefficients		Standardized Coefficient		P value
Model	B	Standard error	Beta	t	Significant
Constant	192.276	231.153		.832	.413
Amount of rain	.263	.236	.206	1.113	.275

Dependent Variable: amount of coffee

From Table 3 above, result indicates that if there was no rainfall the total coffee production would be 192.276 tons. On the other side the results shows that if rainfall increases by a unit (1 mm), the coffee production will rise by 0.263 tons. The results also indicate that, all the regression coefficients (192.276 and 0.263) have insignificant effect on amount of coffee (p-values are 0.413 and 0.275 respectively). This implied that, as much as rainfall required to give a satisfactory production on the other side production may increase at non significant rate. Taking Rainfall amount recorded in a year 1986/1987 was 1139 mm while the amount of coffee recorded in the same period was 392 tons. In this situation farmers expected to have more production but they could not get it. The same experience appeared for years 1990/1991, 1996/1997 and 2001/2002. Three quarters of the respondents (75%) agreed that, the decreasing of coffee production from one year to another was largely due to non-climatic factors although rainfall is playing part but at the small rate.

According to the data from Kigoma district agriculture office and Kigoma weather station, annual rainfall and annual coffee production (1981-2010) show a decreasing trend.

Some of the years have high rainfall but low production while others have low production but high rainfall. This indicates that, coffee production in the area does not only depend on rainfall, there must be other factors like shortage of agricultural inputs such as fertilizers and pesticides which influence coffee production in the study area.

4.5 Farmer's Perception on Climate Change and Variability

Climate change is perceived differently by various stakeholders even within the same level. Through the household interviews, it revealed that, farmers had different understanding about climate variability. Over half of the farmers (55%) explained climate variability as the extended dry season due to shifting rainfall. A third of the respondents (33%) understood climate variability as decreases in rainfall while 14 respondents (12%) defined climate variability as increase in temperature and rainfall change; these respondents perceived the temperature to be hotter today than in past days.

On the other hand, when respondents were asked about the causes of climate variability, most of them (95%) mentioned deforestation and degradation of water sources as the major factors of climate change. Other factors mentioned included overgrazing and bush fire (3%). However, a smaller number of respondents (2%) perceived climate change and variability as a result of breaking traditional rules laid down by their forefathers. They claimed that during their time, drought could be simply solved by a rain maker. Farmers' perceptions to changes in temperature and rainfall variability are closely similar to empirical results from the analysis of rainfall and temperature trends using the data obtained from Kigoma meteorological station.

Trend analysis of rainfall data (Fig. 4) indicates that total annual rainfall has been decreasing over the years. More pronounced decrease being from 1173 mm in 1982 to 742 mm in 2005. Farmers' perceptions on rainfall trends in the area are also closely similar to IPCC report (2007) which forecasted increasing warming in most part of western Tanzania. Similarly, the International Institute for Environment and Development (IIED) forecast arise in temperature of between 2 and 4ºC and decline in rainfall over western Tanzania (IIED, 2009).

According to the respondents, over the last 15 years during September to December the area was becoming warmer. The majority (95%) declared that rainfall onset has changed because they used to have rainfall at the beginning of October but nowadays rains start in the middle of October or at the beginning of November. Similar results were reported by Maddison (2006) whereby a significant number of farmers in eleven African countries mentioned that temperatures had increased and precipitation had declined. Majule *et al.*, (2008) has also reported similar results. Other views from the respondents were about the absence or drying of some water sources like rivers, natural spring and natural water-hole in the area implying changes in rainfall amount. The respondents' views were also closely similar to empirical analysis that showed occurrences of drought in most part of Tanzania between 1983 and 1992 (URT, 1998).

Also an analysis by Hatibu et al. (2000) revealed that more than 33% of disasters in Tanzania over 100 years period were related to drought. Interviews conducted in the study area included the assessment of farmers' awareness of years wherein drought has been observed. Most farmers mentioned 1974, 1979, 1982, 1983, 1992, 1996 and 1999 as the most severe drought years and heavy rainfall of 1997 and 1998. However, some of the farmers could not recollect exactly the dates of past droughts.

In all drought years, the main problem experienced by the farmers was absence of rainfall which resulted into shortage of water in the area.

Table 4: Farmers perception on Climate Change and Variability

Farmers perceptions on definition of Climate change and variability	Frequencies	% of response
Climate variability as extended dry season due to shifting rainfall	70	58
Climate variability as decreases in rainfall	50	42
Farmers perceptions on causes of Climate change and variability		
Deforestation and degradation of water resources is primary factor of climate change and variability	114	95
Overgrazing and bush fire as the causes of climate change and variability	4	3
Climate change and variability as a result of breaking traditional rules laid down by forefathers	2	2

4.6 Coping and Adaptation Strategies

Farmers were asked about management practices (coping and adaptive strategies) for reducing risk and vulnerability under climate variability on coffee production. Coping strategies are the actual responses to crisis on livelihood systems in the face of unwelcome situations, and are considered as short-term responses (Boko *et al.*, 2007). Adaptive strategies are the strategies in which a region or a sector responds to changes in their livelihood through either autonomous or planned adaptation (Smit and Skinner, 2002). The majority (95%) of the farmers interviewed were aware of the connection between coffee production and climate variability.

However, few of them have developed some types of coping and adaptation measures which help them to address short-term and long-term impacts of climate change and variability. Among the interviewed households, 53% adopted a range of practices in response to perceived climate change. The most common practices included switching to non-farming activities (7%), engage in causal labor (5%), receiving credit from coffee cooperatives union (3%), rain water harvesting (9%), mulching to reduce evaporation (4%), terracing/contouring to avoid soil erosion and to improve soil fertility (15%) and planting hedge and shade tree to mitigate increased temperature due to direct sun rays impact (5%). Other responses included planting trees (3%) and changingfertilizer application (2%). On the other hand, 47% of the farmers responded that they did not experience serious farming problems related to weather change. Therefore, they did not take any coping or adaptation strategies during the extreme weather events. Table 4 shows the coping and adaptation strategies practices by the farmers in Kigoma District.

Table 5: Farmers' coping and adaptation strategies in Kigoma district

Coping strategies	%	Adaptation strategies	%
Switching to non farming activities	7	Rain water harvesting	9
Engage in causal labor	5	Mulching to reduce evaporation	4
Cooperatives union creditserosion	3	Terracing/contouring to avoid	15
Reducing temperature variations	2	Tree planting	5

4.6.1 Coping strategies

Coping strategies against low production experienced during the extreme weather events as depicted in Table 5 includes switching to non farming activities in order to extend household income, engaging in causal labor, and receiving credit from coffee cooperatives union. However, the extreme weather events that occurred in the area were in most cases reported to have no serious impacts on coffee production. According to the respondents, the main strategy during low production in the area was switching to non-farm activities.

4.6.2 Adaptation strategies

In response to the impacts associated with climate change and variability, farmers in the study area are implementing different adaptation measures to cope with both expected and unexpected variability of rainfall. The strategies are mainly related to the local production systems and the adaptation of local people to the surrounding environment. The strategies to cope with changes and variations of rainfall are different depending on knowledge and economic status of the farmers. The adaptation strategies include rain water harvesting, mulching to reduce evaporation, terracing/contouring to avoid erosion and improve soil fertility. Other strategies include planting hedge and shading trees to mitigate increased solar brilliance, reducing temperature variations and helping retain moisture. Respondents indicated that rain water harvesting is effective and widely used as one of the coping mechanism to rainfall and water resources variability in the study area. The techniques for rainwater harvesting include the construction of water reservoir and digging shallow basin for collecting run-off water.

Adaptation strategies have been advocated as having the potential to increase productivity in the face of the impact of climate change and variability. Majule *et al*., (2007) clearly indicated some types of adaptation measures which are more appropriate to address short-term impacts due to climate variability. Such measures are primarily used to address variability in farming community. Also the IPCC and TAR (2001) distinguishes several types of adaptations which are mostly used by farmers in most African countries. Agricultural systems adaptation to climate conditions is well documented (CAST, 1992; Rosegrant, 2002; Easterling*et al*., 1993; Kaiser *et al.,* 1993). However, good farming practices help to conserve soil and water and in so doing also make it easier to adapt to climate variability while at the same time lessening its impact. Studies on climate change (Boko, 2007; Niang, 2007) suggest that, coping and adaptation strategies to climate variability should be sustainable and environmental friendly. Survey from these studies indicate that, farmers in rural areas use temporary solution that some time result into habitat changes and affects the surrounding environment.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The global concern on climate change and its implication on agriculture, which is the most vulnerable sector to climate change, prompted the present study on the assessment of weather and coffee production trends in the highland zone of Kigoma District. The study has revealed that coffee production and rainfall in study area have been decreasing over the thirty years (1981-2010). And farmers are aware that agriculture production has been decreasing over time. At the same time, climate has continuously been adversely changing over time. Data shows that rainfall amount has been decreasing over time while temperatures have increased. Consequently, farmers have adopted and developed coping strategies to combat drought and desertification in the area.

Although rainfall and coffee production have been decreasing over the thirty years, overall, this study concludes that; the decline in coffee production in highland zone of Kigoma District is not strongly attributing to the decline of rainfall and its variability. However, while the decline could be attributed to other factors, the trends of rainfall, temperature and dry spells indicate that the study area is vulnerable to the impact of climate change and variability.

5.2 Recommendation

i. This study recommends the design of appropriate strategies for reducing vulnerability to climate change and variability. On the same token, there must be deliberate efforts for improving and protecting the environment as well as providing environmental management education to farmers.

ii. On the other hand, there is a need to include the diversification of agricultural production, improving agricultural inputs and implements so that rise standard of lives of the farmers. Adaptation strategies in rural areas should be done by helping farmers to use their local knowledge in combination with the introduced innovation to enhance local adaptations to climate change and variability. Stakeholders involvement and joint action among researchers, agricultural officers, farmers and policy markers would likely help to reduce this problem.

5.3 Recommendations for further studies

Because this study has indicated that there was no strong evidence for attributing the decline in coffee production to climate change and variability meaning that the decline could be attributed to other factors, further research is recommended to study the interaction between and among various socio-economic factors and climate variables and their implications in coffee production in the study area and other places in Tanzania.

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APPENDICES

Appendix 1: Household questionnaire

Household questionnaire

Dear household head,

As one of coffee producer, your house hold has been selected so as to provide information that could be used to assess the effect of climate variability in coffee production. I assure you that, all the information will be provided are special for academic purpose and not otherwise. Therefore, you are friendly requested to respond truthfully to the following questions. I thank you in advance.

A: General information

1. Name of interviewee…………………………………………………………..
2. Date of interview……………………………………………………………..
3. Questionnaire number………………………………………………………..
4. Village name…………………………………………………………………
5. Ward…………………………………………………………………………
6. Division………………………………………………………………………
7. District……………………………………………………………………….

B: Household characteristics

8. Household number………………………….
9. Name of household head……………………
10. Age of respondent…………………………
11. Sex of respondent…………………………Male = (1) or Female = (2)
12. Marital status…………Married = (1), Single = (2), Divorce = (3) or Widow = (4)

13. Level of education of respondents…………………………………
14. Main activity of Household……………………Crop production = (1), Livestock production = (2), Both crop and livestock production = (4). Or others = (5).

C: Farm activities and farmers perception on climate variability/change

15. When did you start to cultivate your farm? ……………………………….
16. How many acres did the household cultivate?
17. Did the rainfall enough for production……………Yes = (1), No = (2)
18. Have you experienced any shifts in the rain seasons in the year over the past 20 years? ....Yes = (1), No = (2)
19. Which year between 1990 to 2010 on which the rainfall not enough? List them……………………………………………………………………
20. Which year between 1990 to 2010 on which the rainfall was average? List them…………………………………………………………………….
21. Which year between 1990 to 2010 on which coffee production not enough? List them……………………………………………………………………….
22. Which year between 1990 to 2010 on which the coffee production was more than enough? List them………………………………………………………..

23. List the crop acreage and total amount of coffee production from 2005to 2009 season.

Type of crop	Year	Acreage	Harvest bags	Average
Coffee				

24. What do you understand by the term climate variability?
25. Are you aware of the fact that currently the climate has been varying? ……Yes= (1), No = (2)
26. If yes, what do you think are the indicators that the climate has been behaving abnormally?

    (i)...……………………………………………………………

    (ii)……………………………………………………………..

    (iii)……………………………………………………………..

    (iv)……………………………………………………………..
27. Do you think climate variability has been affecting coffee production in the area? …………..Yes = (1), No = (2)
28. Why do you think so? Please explain the reasons for your response in question
29. What used to be the state of temperature before 1980s?

    (a) warm (b) cool (c) more extreme (c) don't know
30. Have you ever experienced any droughts in the area for the last 30 years? Yes = (1), No = (2)
31. If yes, what are the causes of drought in your village? List them…………………
32. What are the effects related to drought on coffee production? List them…………………………………………
33. Have you made any adjustments so as to reduce the effects? …………………….. Yes = (1), No = (2). If yes, what are they?
34. What do you recommend to be done that will help farmers to better cope with problems caused by climate variability?

Checklist for key informants:

General information

Village………………………………………………

Ward…………………………………………………

District………………………………………………

1. What do you understand by the term climate variability?

2. What are the indicators of climate change/variability?

3. How many rain seasons do you have in the area?

4. Has the rain frequency changed for the past 20-30 years ago?

5. Which month in the year did rains begin and end the past years before 1990

6. Has the temperature been decreasing over the past 20-30 years ago?

7. What used to be the total annual production of coffee in the area?

8. Are there any factors contributing to low production in the area?

Appendix 2: Location of Agro Ecological Zones in Kigoma region, Tanzania

ZONES	ALTITUDE RANGE AND COVERAGE	GENERAL MORPHOLOGY	DOMINANT SOIL	MAIN ECONOMIC ACTIVITY	ANNUAL RAINFALL
The Highland Zones	Altitude range from to1750m above sea level. The zone is divided into two parts: the south which covers highlands and the Mahale Mountains	Gentle plain moderately slopping hills and plateaus	Deep and Acidic soil.	**Agriculture:** maize, beans, bananas and coffee. **Livestock:** cattle/goats. **Tourism:** national parks.	1300 to1650 mm annually
The lowland zones	Altitude range from 1200m to 1500 above sea level. Extension of the Western plateau and covers much of the East and South East of Kigoma.	Gentle plain	Red soil to sandy.	**Agriculture:** maize, beans, palm oil and cotton. **Livestock:** Few cattle.	850 to 1100 mm annually
The lake zone	Altitude range from 1000m to 1200 above sea level. Covers a narrow strip along lake Tanganyika: the valley of River Malagarasi and area of Kigoma town.	Flat plain	Sandy, Clay and loam soil.	**Agriculture:** rice, cassava, palm oil, maize, cotton and various vegetable. **Fishing** **Livestock:** Few cattle.	650 to 1000 mm annually.

Source: Regional Commissioner’s Office, Kigoma, 2006

Appendix 3*: Coffee Productivity by villages in tones, in highland zone of* Kigoma district 2001/2005

Village	2000/2001	2001/2002	2002/03	2003/04	2004/05
Kalinzi	122	70	66	56	85
Matyazo	87	35	52	49	69
Mkabogo	65	45	54	45	47
Mkigo	62	32	43	39	60
Nyarubanda	60	38	40	33	49
Mkongoro	45	30	33	28	39
Total	**441**	**250**	**288**	**250**	**349**

Source: Regional Commissioner's Office, Kigoma, 2006

Appendix 4: Estimated Area under Major Cash Crops Production in Kigoma region from 1999/00 - 2003/04

Year/Crop	**1999/00**	**2000/01**	**2001/02**	**2002/03**	**2003/04**	**Average**
Cotton	20	82	24	180	1,601	1,907
Tobacco	2,090	2,750	1,230	1,694	1,808	9,572
Coffee	11,950	5,487	4,149	5,083	5,405	32,074
Oil Palm	7,100	8,111	8,544	8,664	9,810	42,229
Ginger	775	685	562	495	573	3,090
Groundnuts	3,803	7,800	8,638	7,955	10,846	39,042
Irish Potatoes	320	368	372	1,029	2,842	4,931
Horticulture		420	561	606	590	2,177
Total	**26,058**	**25,703**	**24,080**	**25,706**	**33,475**	**135,022**

Source: Regional Commissioner's Office, Kigoma, 2006

Appendix 5: Total monthly rainfall for thirty years in Kigoma district from 1981-2010

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1981	106.5	113.8	204.4	116.3	128	0	0	19.7	2.6	117.5	151.5	166.2
1982	153.2	60.3	50.3	179.8	107.7	8.7	0	0	1.2	162.7	342.2	107.4
1983	92.9	79.3	99.1	147.4	21.3	0.5	TR	67.1	TR	139.1	163.1	113.8
1984	63.1	72.1	79	117.3	63.8	0	0	0	4.1	131.1	206.8	109.5
1985	101.1	110.2	104.4	131.1	11.2	27.6	0.1	0	2.1	22.3	228.6	241.9
1986	206.3	174.2	60.4	82.1	47.6	0	0	0	21	90.3	189.1	268.1
1987	55.6	67	74.1	219.9	17.7	4.1	0	0	95.9	91.2	104.8	78.4
1988	92.7	47.5	133.1	208.3	0.6	0	1.2	4.2	7.2	114.9	109.4	303.5
1989	149.4	114.3	141.8	130.2	24.3	0.3	2.2	0.1	19	77.4	138.8	121.1
1990	140.4	184.5	260.6	132.7	88.8	0	0	0.3	27.8	29.4	58.4	198.4
1991	90.7	118.5	35.5	86.6	147.1	0	0.1	3.6	81.9	122.1	183.3	239.5
1992	130.1	49.8	88.5	125.7	60.4	9.2	6	0	2.2	66.9	257.4	137.4
1993	154.3	47.9	157	67.1	28.6	0	0	5.9	0	21.7	118.2	171.9
1994	120.2	83.8	119.1	169.3	59.4	0.1	4.3	0	15.6	105.2	92.5	213.7
1995	223	89.5	146.9	120.6	23.7	56.3	0	0	7.5	160	100.9	58.2
1996	135.9	227.4	180.5	108.6	145.4	2.1	0	0	33.3	77.4	99.6	144
1997	193.1	15.6	107.2	112.2	86.9	0	0	0	0.1	227.6	122.4	157.3
1998	172.5	73.8	214.8	75.4	81.3	0.1	1.3	0	11	60.7	126.6	121.4
1999	125.1	30.5	192.2	141	0.1	0	0	23.7	21.2	71.6	260.9	123.8
2000	72.5	98.9	156.7	59.9	32	0	0	0.3	2	53.5	186.1	150.2
2001	161.5	65.6	228.3	116.1	39	17.7	0.8	22	35.6	64.3	71.8	90.8
2002	272.1	26.3	168.3	241.4	4.3	0	0	0	0	29	184.4	109.3
2003	164.7	153.1	161	170.9	6	8.3	0.1	3.8	22	73	91.8	134.9
2004	178.6	74.4	160	54.4	0.1	0	0	0	47.9	76.6	89.9	183.9
2005	264.8	29.6	89.3	35.1	81.5	5.5	0	0.2	0	22.7	153.7	59.8
2006	105.3	132.7	95.6	181.4	106.1	0	4.1	0.7	20.6	31	220.2	241.1
2007	96	22.2	132.3	123.5	53.1	12.2	0.1	0.3	11.4	56.4	191.9	95.8
2008	234.8	191.5	135.4	125.2	0.1	13.2	0.2	0.1	4.2	78.3	142.4	145.1
2009	62	142	190.2	167	24.4	18.4	0	0.1	2	23.2	148.7	86.8
2010	75.4	56.1	198.4	82.9	111.9	5.6	0.5	0	16	60.2	100.5	158.1

Source: Kigoma Metrological Station, 2010.

Appendix 6: Coffee production and Rainfall in highland zone of Kigoma district from 1981 to 2010

Year	Annual rainfall	Production in tones
1981	1126.5	706
1982	1173.5	736
1983	923.6	675
1984	846.8	580
1985	980.6	687
1986	1139.1	392
1987	808.7	518
1988	1022.6	683
1989	918.9	457
1990	1121.3	419
1991	1108.9	509
1992	933.6	494
1993	842.6	435
1994	984	500
1995	986.5	566
1996	1154.2	393
1997	1022.4	145
1998	969.8	210
1999	990.1	268
2000	812.1	441
2001	913.5	250
2002	1035.1	288
2003	989.6	250
2004	865.8	349
2005	742.2	320
2006	1138.8	540
2007	791.9	398
2008	1070.5	420
2009	864.9	347
2010	865.6	450

Source: District Agricultural and Livestock Development report (2010)