Implications of Climate Variability on Small Scale Fishing Activities and the Fishers' Adaptive Capacity in the Kafue Flats of Zambia

By

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I dedicate this work to my family and friends. Thank you all for the support.

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LIST OF ABBREVIATIONS

ACF/FSRP	Agricultural Consultative Forum/ Zambia Food Security Research Project
ADB	African Development Bank
AIDS	Acquired Immune-Deficiency Syndrome
CVC	Climate Variability and Change
CSO	Central Statistical Office
DJF	December, January and February
DoF	Department of Fisheries
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
HIV	Human Immune-deficiency Virus
IUCN	International Union for Conservation of Nature
IPCC	Inter-governmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JJA	June, July and August
MAB	Multi-Agency Brief
MAM	March, April and May
MTNER	Ministry of Transport Environment and Natural Resources
NDBI	Normalized Difference Built-up Index
MNDWI	Modified Normalized Difference Water Index
NRSC	National Remote Sensing Centre

UNEP/WCMC	United Nations Environment Programme/ World Conservation Monitoring Centre
SAVI	Soil Adjusted Vegetation Index
SON	September, October and November
SPSS	Statistical Package for Social Sciences
WGII	IPCC Working Group II
WWF	World Wide Fund
ZDA	Zambia Development Agency
ZMD	Zambia Meteorological Department

OPERATIONAL DEFINITION OF KEY TERMS

FISHING: Mbulo and Mulikelela (1999) define fishing as "any act which is directed at the taking, killing or injury of any fish for household supply or supply to any market or industry".

A FISHER-FOLK: Is any person who undertakes fishing as a regular occupation, draws their income from fishing and sustains their livelihood from fishing. Fishers may undertake fishing for the supply of fish to their households, to the market or industry. They may be male or female (Mubanga 1992).

STRATUM: This is an area that is arbitrary divided into a number of smaller areas in order to design a Frame Survey (FS). Field operations of the survey take place within the established Stratum (CSO 2006).

FISHING VILLAGE: This is a permanent place where fishers reside for the most part of their life and intend to develop in terms of provision of social amenities.

LIVELIHOOD: This is an occupation that provides income to live on. It comprises of people's capacities, possessions, revenue and activities essential for securing life's necessities. A livelihood is sustainable only when it allows individuals to deal with and recuperate from the social, economic and ecological shocks and stresses and improve their welfare and that of upcoming generations without damaging the natural environment or resource base.

CLIMATE VARIABILITY: This is the yearly fluctuation of the climate either above or below a certain long-term average value.

VULNERABILITY: FAO (2009a) defines vulnerability as "the susceptibility of groups or individuals to harm as a result of climatic changes". Vulnerability to climate change results from social, economic, cultural, political and institutional dimensions that entrench human lives (WGII 2014).

ABSTRACT

Small scale fisheries serve as a "safety net" to the landless poor and significantly contribute to nutrition, food security, sustainable livelihood and poverty alleviation especially in developing countries such as Zambia. In spite of this substantial contribution, fisheries are highly susceptible to climate change and variability. The main aim of this study is to investigate the implications of climate variability on small scale fishing activities and the fishers' adaptive capacity in the Kafue Flats of Zambia. Climatic data from Mumbwa, Kafue Polder, Mt Makulu, Magoye and Lusaka City meteorological stations is examined for the monthly, seasonal and annual variabilities with a central focus on the mean rainfall, temperature and wind speed over the 1982-2011 period. Additionally, the periodic size variation of the Kafue flats catchment area and its effects on the fishing activities are explored using satellite imagery in change detection analysis, employing ARC GIS 10.1 and ENVI 4.8. Further, the study explores the livelihood strategies of the fishing communities in determining their adaptive capacity to climate variability effects. Accordingly, the data sets are analysed using MS EXCEL, SPSS, ANCLIM, TREND TOOL, to establish climatic trends and deduce evidence of change and variability in the Kafue flats. Using snowball sampling technique and household survey, 110 fisher-folk were selected for the study. Besides, dissemination of face-to-face- questionnaires and key informant interviews are employed in this study. Climate variability analysis revealed that strong winds, storms, high rainfall and floods have adverse effects on the fisher-folk and their fishing activities. Thus, 90.9% of the fisher-folk indicated that heavy stormy rains have a larger potential to wreak havoc and cause death due to boat submergence. In addition, 95.5% of the fisher-folk stated that fishing activities do not take place during strong winds and heavy storms until calm weather conditions prevail. It is also established that the fisher-folk who are inclined to remain in a declining fishery are those restricted by a lack of alternative livelihoods and poverty. For instance, nearly half (44.5 %) of the fisher-folk interviewed lack alternative sources of livelihood. The conclusion from the study is that, climate variability has a wide range of impacts on fisheries and fishery dependent households. The explicit and localized impacts of climate variability on fisheries include reduced primary productivity, decrease in lake water levels and fish catches resulting from reduced precipitation and high run off. Therefore, there is need to enhance resilience and adoption of sustainable mitigation and adaptation strategies. The fisher-folk should be educated on alternative livelihoods to enable them cope in an event where climate change and variability severely impact on fisheries.

KEYWORDS: Climate Variability, Fisher-folk, Vulnerability, Livelihood, Kafue Flats

CHAPTER 1 : INTRODUCTION

1.1 Background

The fisheries sector is of high importance in terms of trade, food security and livelihoods; nevertheless, its magnitude varies greatly across countries (Katikiro and Macusi 2012). FAO (2007) noted that the world's fisheries support livelihoods of over 2.6 billion people providing an average annual per capita protein intake of 20%. According to Katikiro and Macusi (2012), the rural people throughout the world greatly benefit from small scale fisheries in terms of food, employment and economic welfare. Fisheries often function as a "safety net" to the poor landless people in times where other livelihoods fail (FAO 2005). For instance, along the coast and in-land areas of West Africa, several millions of households favourably depend on fishing for their livelihoods with fisheries contributing 17 % of Gross Domestic Product (GDP) and generating up to a third of national export revenue (Katikiro and Macusi 2012). In addition, fish production provides significant economic opportunities for the poor such as enhanced rural economic growth and commerce (ACF/FSRP 2009). For example, FAO (2005) noted that among the millions of people engaged in fisheries and aquaculture, at least 90% are small-scale fishers. However, fishing communities are generally known to be amongst "the poorest of the poor" (FAO 2009b). FAO (2009b) noted that inland fisheries for example have been sidelined in relation to food security and poverty reduction. Interestingly, small scale fisheries are considered as essential engines for financial development and livelihoods in far-flung rural areas of the world with less or limited economic activities (FAO 2005). Thus, some fishers completely rely on fisheries as a source of livelihood. Nevertheless, fisheries form diverse livelihood strategies particularly for inland fisheries in developing countries (Allison and Ellis 2001). In Zambia, the Department of Fisheries through the Fisheries Act, Cap 22 of 2011 of the Laws of Zambia, manages and ensures sustainable utilization of the country's fisheries resources (DoF 2011). Henceforth, Zambian fisheries contribute an average of 1.2% to GDP (Musumali *et al.* 2009) and ensure national food security by providing 40% of the country's animal protein diet (ACF/FSRP 2009).

Although agriculture is deemed as the utmost occupation for many Zambians, a number of people in different parts of the country also depend on fishing as an alternative source of livelihood (ZDA 2011). Zambia's rivers, lakes and swamps contain 15 million hectares of water thereby providing a basis for extensive freshwater fisheries. For instance, fisheries play a significant role in contributing to livelihood and animal protein intake of the people in the Kafue Floodplain (DoF 2011). Despite the fact that demand for domestic fish consumption outstrips production, everyone in Zambia enjoys fish irrespective of their socio-economic status (ACF/FSRP 2009). ACF/FSRP (2009) stated that fish generally provides a high nutritional value mainly for vulnerable groups. In recent years, demand for fish has thus been growing strongly in Zambia due to increase in both population growth and urbanization (ZDA 2011). In order to increase fish production and improve nutrition, the Zambia government has made tremendous efforts through viable resource utilization of aquaculture and capture fisheries (ZDA 2011). ZDA (2011) indicated that fisheries and aquaculture contribution to GDP averaged 3 % out of the 18 % by the agricultural sector in the year 2011.

1.2 Climate Change and Fisheries

FAO (2008) noted that conservative agriculture has less profound links than fisheries and their ecosystems. Hitherto, MAB (2009) noted that efficiency in fishery production is often linked to the well-being and functioning of the ecosystems. Moreover, Brander (2007) observed that alterations of fishing effort is the only control human-beings can solely apply on a fishery's output. According to UNEP-WCMC (2006) ; MAB (2009), estuaries, mangroves, coral reefs and seagrass beds offer substantial ecosystem amenities such as nurseries for fledgling fish. However, these fishery ecosystems are susceptible to impacts of climate change among other stressors (UNEP-WCMC 2006; MAB 2009). For example, rise in temperature and acidity, reduced dissolved oxygen and variations in salinity have detrimental effects on fish (Roessig *et al.* 2004). MAB (2009) further observed that temperature and primary productivity of the marine environment are severely affected by climate change. Moreover, WWF-Zambia (2004) anticipated that the occurrence of extreme weather and climate events could bring about more disastrous floods and droughts. For instance, the dams that formerly held large capacities of water may dry up as result of climate variability thereby negatively affecting water supply (WWF-Zambia 2003). Climate dynamics are generally known to influence the distribution and productivity of natural resources such as fisheries which support the livelihoods of fisher-folk globally (Allison 2005). Climate change has been happening for many millions of years and is as old as the atmosphere itself (Clark 2006). Allison *et al.* (2009) observed that for as long as the planet's climate continues to change, there will be profound consequences for fisheries, populations, species and ecosystems. For instance, the International Panel on Climate Change (IPCC) acknowledged that particular areas in the world have experienced variations in annual mean rainfall (Clark 2006). This is due to the increase in the severity of extreme weather events resulting from the changes in the world's climate (Clark 2006). Moreover, FAO (2009a) noted that diverse geographic areas, countries, social groups and individuals will experience variable climate change impacts. For example, rainfall is projected to upsurge in high latitudes due to climate change (MAB 2009).

Although the fishing industry is very beneficial in most countries of the world, it is among the many sectors that have been predicted by the IPCC to be affected by climate change and variability the most (IPCC 2007a). Meanwhile, rising global atmospheric temperatures already affect marine and freshwater fisheries in certain areas of the world. For example, coastline fishers in Bangladesh encountered intensified hurricane occurrences resulting from thermal expansion of the oceans (FAO 2009a). Consequently, in 2007, the IPCC indicated that damage of coastline wetlands, bleaching of coral reefs and variations in the supply and schedules of fresh water currents are among the numerous risks that climate change imposes on aquatic systems (Orr *et al*. 2005). Furthermore, direct and indirect impacts of climate change such as increase in sea level, modifications in the frequency, intensity and distribution of tropical storms will affect fisheries in multiple ways (FAO 2009a). For instance, displacement and migration of coastal communities and other human populations will take place (FAO 2009a). Undoubtedly, as pointed out by Roessig *et al*. (2004), communities of humans who harvest fish stocks are most likely to be affected by the changes in fish distribution and abundance. However, climate change makes some regions more vulnerable than others; thus Africa is said to be more susceptible to climate change than other regions of the world (IPCC 2007a). This is so because a large part of the less developed countries' economies depend on sectors like agriculture and local natural resources which are susceptible to climate shocks. Additionally, lack of capacity in terms of human, financial, natural, institutional and technological resources as well as diverse livelihood strategies construe livelihood vulnerability in various contexts (Islam *et al*. 2014). Further, climate change influences people's livelihoods severely through loss of crops due to severe floods and droughts, thereby resulting in increased levels of hunger, malnutrition and diseases (IPCC 2007a). For instance, ADB (2013) noted that heavy reliance on rain-fed agriculture (including livestock production) by the communities in the Kafue flats of Zambia makes them more vulnerable to climate change impacts. These communities are less adept to climatic shocks because of insufficient capacity to safeguard themselves (ADB 2013).

Globally, many scientists are concerned with climate change impacts for fisheries and fish merchandise despite the slight effort made to integrate observed changes into management models and paradigms (Clark 2006). Nevertheless, projections of future climate conditions indicate further impacts of relatively small temperature changes on the distribution and abundance of fish species (IPCC 2007a). Goulden (2005) observed that the impacts of climate variability are more severe in societies that are heavily reliant on natural assets for their livelihood. This is also true for societies that experience extreme climate shocks like floods and drought (Goulden 2005). Disease, conflict and increased population pressure constitute other sources of stress to the livelihoods of such societies (Goulden 2005). In general, climate change affects four components of food security i.e. availability, stability, accessibility and utilization (Clark 2006).

Zambia has a long history of droughts and floods, hence climate variability is often related to anthropogenic climate change and natural climate variability (ICUN 2007). For several decades, there have been significant departures in the average state of the Zambian climate system due to climatic hazards and extreme events experienced over time. According to MTENR (2007), the most noticeable extreme climate hazards included increased temperatures, drought, seasonal floods and flush floods among many others. Moreover, Bwalya (2010) added that the country had recorded an estimated 0.6 degrees Celsius increase in temperature for every ten years since 1970 while the last three decades also recorded reductions in rainfall amounts. Consequently, extreme climate shocks and stresses negatively affect people's livelihoods in terms of increased food insecurity and health issues (Bwalya 2010). ADB (2013) observed that floods and droughts generally affect the Kafue Flats area. For instance, in 1994, fishing camps and some settlements (mud-brick houses) alongside the Kafue River were flooded. The torrential currents displaced the local people from their homes and certain parts of the country like Monze and Namwala towns were disconnected from the rest of the country when two bridges collapsed from the 1994 floods (ADB 2013). Bwalya (2010) further stated that Zambia will continue to be vulnerable to future climate change and variability because of the increased intensity and magnitude of extreme events that climate change entails. Additionally, the 2010-2070 climate scenarios indicate temperature increase and rainfall decrease of 2 degrees Celsius and 8-10% respectively (Bwalya 2010).

1.3 Statement of the Problem

According to Badjeck *et al.* (2010) , at least 90% of the world's fishers and fish traders is made up of small-scale fisher-folk. Over the decades, global warming effects on the livelihoods of the world's 36 million fisher-folk who depend on fish for food security has raised great concern (Badjeck *et al.* 2010). This is so because fish provides at least 20% of dietary animal protein for over half a billion people globally (Badjeck *et al.* 2010). Although fishing remains the most predominant economic activity in most countries, the small scale fisher-folk are more vulnerable to climate variability due to their poor adaptive capacity (Delgado and Abbate

2013). Conway *et a*l. (2005) noted that variations in temperature and wind speed patterns including rainfall variability have on-going impacts on the fisher-folk living close to the shores of major lakes, wetlands and river flood plains. Considering the social and economic relevance of fisheries, climate change constitutes a tremendous threat not only for the million livelihoods of people in West Africa (Katikiro and Macusi 2012) but also other coastal African countries including Zambia.

The Kafue basin of Zambia has experienced an increase of 1.3ºC in annual average temperature and a decrease in mean rainfall of 1.9mm/month over the last four decades (ADB 2013). Thus, the Kafue basin has had less predictable and shorter rainfall seasons (ADB 2013). For instance, the intensity and frequency of droughts and floods as well as the number of people affected changed significantly during the 2000 - 2007 period (ADB 2013). ADB (2013) observed that the Kafue flats are experiencing the effects of climate change, particularly more frequent flooding and drought conditions causing uncertainty in the reliance and timing of water available for fish nurseries and catching grounds. Environmental pressures from other land uses in the region are also potential threats to the health of this ecosystem and the supporting fishery (ADB 2013). These impacts of extreme climate change (floods and droughts) as well as the high population density are likely to be severe on the livelihood activities of communities around the Kafue flats (ADB 2013). Moreover, climate variability has had an effect on the fishing industry in general and spinoff effects on local livelihoods and food security. Henceforth, examination of fisheries adaption to climate uncertainties is very important (FAO 2009a).

Studies conducted by Mahon (2002) and Islam *et al.* (2014) examined the climate change vulnerability and lack of adaptive capacity for communities who rely on fisheries. Knapp *et al*. (1998) , Kliashtorin (2001) and Diamond *et al.* (2013) provided evidence on developments and variations in fish abundance and distribution targeting large-scale industrial fisheries. To their credit, Diamond *et al.* (2013) observed a lack of research at the local level on how climate variability affects livelihoods of the tropical majority. Studies conducted in Zambia such as by Jul-Larsen (2003) investigated the benefits and importance of the fishing industry including co-management of fisheries; Haller and Merten (2008) focused on institutional change, power relations and conflicts in the Kafue Flats fisheries; and ICUN (2007) assessed climate change vulnerability in certain parts of Zambia. Thus, the previous studies conducted have not addressed the implications of climate variability on small scale fishing activities and the adaptive capacity of the fisher's in the Kafue Flats, which is the main focus of this study.

1.4 Aim of the study

The primary aim of this study is to find out the implications of climate variability on small scale fishing activities and the adaptive capacity of the fisher's in the Kafue Flats of Zambia.

1.4.1 Objectives of the study

1. Establish trends in mean monthly rainfall, temperature and wind in the Kafue flats over the period 1982-2011.
2. Determine the periodic variation in the size of the Kafue Flats (lagoon/swamps) using satellite images.
3. Assess the implications of climate variability; specifically observed changes in rainfall, temperature and wind on the fishing activities and fishing duration in the Kafue Flats of Zambia.
4. Find out the effects of climate variability on the amount of fish catch and the choice of fishing gear/techniques.
5. Establish the coping and adaptive strategies of the fishing community in the Kafue Flats.

1.4.2 Research Questions

1. What are the seasonal changes in mean monthly rainfall, temperature and wind in the Kafue Flats over the period 1982-2011?
2. How does periodic variation in the size of Kafue Flats affect the fishing activities?
3. What are the implications of the observed changes in rainfall, temperature and wind on the fishing activities and fishing duration in the Kafue Flats of Zambia?
4. What are the effects of climate variability on the amount of fish catch and fishing gear/ techniques?
5. What adaptive strategies do the fisher-folk in the Kafue Flats employ in view of climate variability?

1.5 Rationale

In historical times, fisheries played important roles in shaping the destinies of societies as it attracted high population densities and supported human settlement (Chilonge 2012). For a long time, fishing in certain areas was used as an alternative source of income and food security

(Chilonge 2012). In Zambia, at least 300,000 rural community livelihoods derive much of their income (most of them poor and food insecure populations) from the fishing sector (ZDA 2011). Fishers and fish farmers form the direct livelihoods of the local people obtained from fisheries while indirectly some people are fish traders and processors (ZDA 2011). ZDA (2011) noted that employment, income generation and poverty reduction are among the countless ways in which the fishing sector considerably contributes to rural development in Zambia. For instance, an estimated 60% of the population in Luapula province of Zambia largely depend on fishing as the main source of income (Musonda 2006). However, ADB (2013) indicated that there will be upsurges of 3.6 degrees Celsius and 3 percent by the year 2100 of both average annual temperature and rainfall for the Kafue flats respectively. Besides, climate variability is having an effect on the fishing industry in general and spinoff effects on local livelihoods and food security (ADB 2013). With this in mind, responding to climate change requires a multi-level, interdisciplinary and integrated response as well as public participation. This study will provide knowledge of how the small scale fisher-folk perceive and understand the impacts of climate variability on their livelihood and also the mechanisms used to respond to climatic shocks. Additionally, this study will contribute to the existing practical knowledge on alternative sources of livelihood for the peasant fisher-folk exposed to the impacts of climate variability. Besides contributing to the socio-economic and nutritional value of fishing in Zambia, it is hoped that the research findings will provoke further research on climate variability impacts on fisheries in Zambia and elsewhere.

1.6 Layout of Dissertation

This dissertation consists of five chapters. Chapter one provides an introduction to the dissertation consisting of the background to the study, objectives, statement of the problem, research questions and rationale. Chapter two focusses on the review of literature outlining the fundamental role of fisheries at global, regional and local scales. The chapter further discusses Zambia's fisheries and constraints encountered as well as the impacts of climate change on fisheries world over. Chapter three presents the description of the study area, sampling design, methods of data collection including data processing and analysis. Chapter four presents the research findings through interpretation and discussion of the results. Finally, chapter five gives a general summary of the research findings, conclusions based on interpretation of the research findings including limitations and recommendations arising therefrom.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the relevant literature used to conceptualize the research theme. Firstly, the review gives a synopsis of literature regarding the significance of small scale fisheries to livelihoods at global, regional and local scales; the types of fisheries in Zambia, Zambian fisheries regulations, and the types of operators in Zambia, labour sources, fish trade, processing and marketing as well as the constraints faced in the fishing industry. The chapter further discusses the fundamental role of small-scale fisheries in poverty research, vulnerability of small scale fisheries then proceeds to focus on climate variability impacts on small scale fisheries and livelihood activities of the fisher-folk. Both local and regional case studies are highlighted throughout the chapter and finally the conceptual framework from which the study was adopted is presented.

2.2 Small Scale Fishing

Small scale fishing or artisanal fishing is practiced in most countries throughout the world. Both subsistence and small-scale commercial fishing comprise artisanal fishing. Adams and Dalzell (1994) indicated that artisanal fishing chiefly allows fishing communities to merely put food on their table. Thomas (1995) stated that river fisheries account for at least 40% of the total fish yield in Africa. Thus, local fishermen are among the major coastline resource users in Africa just as in other parts of the world. Campredon and Cuq (2001) noted that artisanal fishing is an essential component of the prehistoric values for people in Senegal and Gambia. Furthermore, Jiddawi and Öhman (2002) indicated that mangroves, coral reefs, sand banks and sea grass beds are the foremost productive fishing grounds throughout the world. For example, fish is a vital source of income for local communities along the western shores of the Indian Ocean. According to Jiddawi and Öhman (2002), fishing still remains a significant part of people's livelihoods in Africa and the world at large ever since the origin of humanity . For instance, in Ghana, marine resources are used for food and economic benefits (Atta-Mills *et al.* 2004). Besides, artisanal fishing is not only the main livelihood opportunity but the source of food security in the Okavango Delta of Botswana (Ngwenya and Mosepele 2007). Similarly, Trimble and Johnson (2013) also noted that artisanal fishing has relatively constructive social and ecological benefits. Socially, artisanal fisheries provide livelihoods for fishing communities and as such artisanal fishing is not only a job but a way of life (Trimble and Johnson 2013). For instance, at least 43 000 fisher-folk in Tanzania are involved in small scale fishing. Sadly however, overfishing has led to huge reductions in productivity and fish stocks in many of the world's fisheries (Pauly *et al*. 2002).

2.2.1 Health and nutrition

Dulvy and Allison (2009) indicated that more than 20% of protein intake for one third of the world's inhabitants emanates from fish and other marine products. Similarly, MAB (2009) also noted that 400 million of the world's underprivileged people obtain at least 50% of proteins and vitamins through consumption of fish. FAO (2005) further observed that fish is fundamental in provision of vitamin A, B and D, calcium, iron and iodine. Besides, an individual's nutritional status may improve even by mere consumption of slight quantities of fish (FAO 2005). According to Prein and Ahmed (2000), fish constitutes 30% of animal protein intake in Asia, 20% in Africa and 10% in Latin America and the Caribbean. Coastline areas and small Island developing states benefit greatly from fish as a source of food security (FAO 2005).

2.3 The Zambian Perspective on Fisheries

Bwalya (2010) stated that Zambia lies in central Africa between latitudes 8^0 and 18^0 S and longitudes 22^0 and 34^0. Seven percent i.e. 53,700 Km^2 of Zambia's surface area is enclosed by water in form of lakes, rivers, swamps and wetlands (Malasha 2007). For many years, availability of these water-bodies provides a booming fishing industry supporting millions of livelihoods (Malasha 2007). There are two main river basins in Zambia namely the Luapula and Zambezi Rivers (Malasha 2007). The significance of fisheries in Zambia cannot go unnoticed because fish accounts for about 55 percent of the national dietary requirements (Choongo *et al*. 2009). FAO (2006) reported that rural and urban households represent 47 percent and 30 percent of fish consumption respectively. Indisputably, fishing provides income to fishermen, traders and to the local government through fish levies. For instance, the artisanal fishery in the Kafue floodplains has been of great importance because it functions as; what Béné (2003) describes as a poverty prevention mechanism for the poorest and the most vulnerable, both within the district as well as for migrants. The Zambian economy benefits greatly from the fishing sector through income generation and employment as well as improved availability of fish as a source of protein (ACF/FSRP 2009). The Central Statistical Organisation surveys of 1997 indicated that, the ratio of fish to household food expenditure had increased from 5.5% in 1993 to 12% in 1996 due to rise in poverty levels (FAO 2006). Ultimately, fishing contributes to poverty reduction for the majority of rural communities in Zambia (ACF/FSRP 2009). Likewise, the Kafue floodplain fishery is one of the major fisheries in Zambia and its widespread floods provide perfect environments for fish breeding and growth (FAO 2006).

2.3.1 Management and legislation of the fisheries sector in Zambia

The Department of Fisheries (DoF) through Fisheries Act, cap 22 of 2011 of the laws of Zambia enforces and regulates fisheries in Zambia. For instance, development and control of fishing, registration of fishers and boats is administered through the Fisheries Act. The Department of fisheries located in various districts of Zambia oversees the implementation of the national fisheries programmes in capture fisheries and aquaculture development (Malasha 2007). It carries out research in capture and aquaculture, in order to achieve a sustainable fishing industry and economic benefits (Malasha 2007). Although the national government is responsible for management of fisheries, the act also provides for community involvement (Malasha 2007).

2.3.1.1 Fish ban or closed season

The Department of Fisheries in Zambia is empowered by Act CAP 200 (1974) to institute a fishing ban to a fishery during a particular period of the year in order to allow fish to increase in quantity, grow and breed (ACF/FSRP 2009). This is also done to give time to fingerlings of fish to pass the vulnerable stage. According to Mbulo and Mulikelela (1999), nobody is allowed to fish during this period as it is the peak period for breeding. Thus; every year, the Zambian government through the department of fisheries implements the 'fishing ban' in order to allow fish to breed in the restricted fishery areas (ACF/FSRP 2009). The fish breeding period runs from the 1st of December to the end of February every year (ACF/FSRP 2009).

Mubanga (1992) outlined the advantages of the fish ban as follows:

- Gives chance for a fishery to regenerate itself.
- Provides opportunity for fishermen/women to concentrate on alternative activities like farming.
- Contributes to reducing the fishing pressure particularly in fisheries which are threatened with over-fishing.

2.3.2 Types of fisheries in Zambia

Zambian fisheries are categorized into large and small water body fisheries (Malasha 2007). Hence, the country has eleven key fisheries belonging to the Congo and Zambezi River basins (Malasha 2007). Below is an examination of a selected fishery.

2.3.2.1 Kafue River

Zambia's largest exporting fishery comes from the floodplain fishery (Malasha 2007). The Kafue River borders the two important supreme fisheries; the Lukanga and the Kafue floodplains (Malasha 2007). Interestingly, both fisheries heavily rely on seasonal flooding for their productivity. The Kafue River is inhabited by *Characid Bycinuslaterlis* and the *Schibed mystus* in their abundance. Therefore, the Kafue flood plains are a *Cichlid Tilapia spp* fishery as shown in figure 2.1 below, lately though, the non-indigenous species *Oreochromisnioticus* has involuntarily overcrowded the swamps through sugar plantation fish farms (Malasha 2007). Consequently, this research study focusses more attention on the Kafue floodplain fishery concentrating mainly on the lower part of the river from Road Bridge, Chanyanya, Chilumba and Nanga fishing sites.

Figure 2.1 : The Cichlid Tilapia spp locally known as "Mpende" caught in the Kafue floodplain fishery

Source: Field work data, 2014.

2.3.3 Types of Fishing Methods

Fishing methods in Zambia include simple crafts such as seine nets, gill nets, traps, canoes, and as baskets shown in figures 2.2, 2.3, 2.4 and 2.5 below (Malasha 2007). Mbulo and Mulikelela (1999) observed that canoes account for 80% of the Zambian fishing fleet. Notably, the CSO (2006) fishery report indicated that the entire Kafue floodplain fishery basically relies on canoes as fishing/ transport boats. For instance, about 2,043 canoes (83.83percent) were found in the Kafue floodplain fishery during the 2006 fishery survey (CSO 2006). In addition, the CSO (2006) fishery report revealed that 330 canoes were found in Stratum I which is the main study area for this research. However, the CSO (2006) fishery report indicated that the number of active marine engines had reduced in the Kafue floodplain fishery, possibly due to increased costs in spare parts and petrol. The most commonly used mesh sizes in the Kafue flood plain fishery range from 2.0 inches (50mm) to 3.5 inches (89mm) (CSO 2006).

Figure 2.2 : Seine and Gill nets

Figure 2.3 : Fishing Trap

Source: Field work data, 2014.

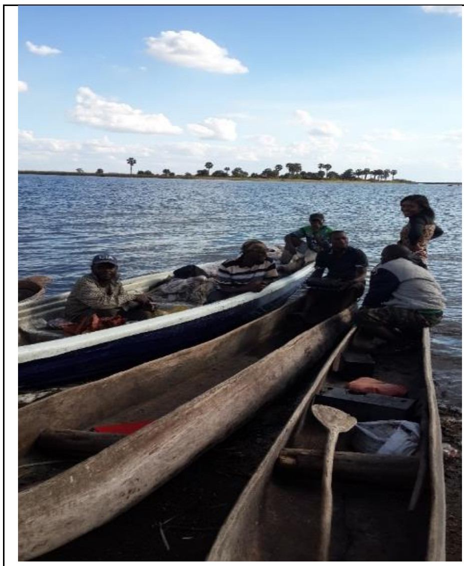

Figure 2.4 : Fishing canoes

Figure 2.5 : Fishing basket

Source: Field work data, 2014.

2.3.4 Types of Fishers

Zambia has two groups of fishers precisely traditional and industrial fishers (Malasha 2007). Traditional fishers are also known as artisanal or small scale fishers who produce fish enough to eat and sale locally with no ambitions to export (Malasha 2007). According to the Fishery and Aquaculture Country Profile by FAO (2006) , traditional fishers are located around each fishery in camps or villages and counts up to more than 25 000 in number. Mbulo and Mulikelela (1999) observed that fishing villages and camps are enlarged through high migration of people due to abundance of fish during certain times of the year. Traditional fisher-folk often dominate in terms of production out-put and labour (Malasha 2007). Usually, women are the major distributors of fish to private and individual traders. By and large, traditional fishery is normally regarded as an open employment division for rural dwellers. Malasha (2007) stated that industrial operators or commercial fishers are essentially found on Zambia's large water bodies such as Lake Kariba and Lake Tanganyika. Nonetheless, fisheries in Zambia are largely artisanal (Malasha 2007).

2.3.5 Labour Sources

By and large, artisanal fishermen handle their fishing activities as a much localised business with little or no external labour other than the family (Malasha 2007). Thus, the fisher-folk are mostly self-employed in this fishing business. Nonetheless, there are a few cases of using hired labour and family assistants (Malasha 2007). For instance, during the survey, one fisher-folk stated that he does not own a boat but hires it from other fishermen. Moreover, cases of hired labour exist or even increase frequently where seine nets are employed in fishing.

2.4 Fish Trade, Processing and Marketing

According to FAO (2009b), fish is widely traded throughout the world. For example, FAO (2009b) observed that at least 37% of live fish is sold internationally while aquaculture accounts for half of global fish supply (Naylor *et al.* 2009). Hence, fresh fish in Stratum I of the Kafue floodplain fishery is sold readily at Chanyanya and Nanga lagoons. Although the roads to these lagoons are dilapidated, the bicycle riding fish traders manage amidst all odds to travel the tough roads all year round while old and tough Land Rovers and Toyotas are able to reach these places during most of the year (Malasha 2007). Nonetheless, marketing of the fresh fish catches is typically "tricky" as claimed by many respondents; they feel that a guaranteed income doesn't exist even if one may have fairly stable catch per boat per day because fish traders may "deliberately" demand for a lower price per Kg or "heap"; this is said to be common when the number of fish traders visiting the fishing village landing points declines. It is also felt by the fishermen that fish traders though not with a visible "union" to speak through are more organised to speak one voice than the fishermen themselves (Malasha 2007). Nevertheless, the fishermen have the alternative of sun-drying and smoking their fish when the catches are higher than can be quickly sold as fresh, bartered or consumed by family (Malasha 2007). The Kafue floodplain being what it is has very scattered, little to no forests in the vicinity hence it is problematic. This is to say that firewood/ wood-fuel for fish processing and cooking remains a very big problem and will or does dictate how and when the fishermen should dispose of their catch. Raring of cattle along the flood plain provides, as observed, the dung used as fuel for both cooking and fish processing since importation of charcoal and firewood is expensive (Malasha 2007).

2.5 Fisheries Constraints

The CSO (2006) fishery report indicated that the flooding regime of the Kafue floodplain fishery has changed since 1977 when the dam construction at Itezhi-tezhi was completed. However, way before the Itezhi-tezhi reservoir was set up, the extent of the floods covered an area between 22 to 60 Km^2 from the river channel which has reduced to about 10 to $15Km^2$ in a good rainy season (CSO 2006). This change has evidently affected fish species production and abundance as the extent and duration of the flood had a strong influence to the reproduction and survival of the fish before 1977 (CSO 2006). Further, the CSO (2006) fishery report indicated that the flooded area provides nesting and nursery grounds, feeding and hiding places for both juvenile and adult fish. Besides, the remaining pools of water are used to provide good traditional seasonal fishing grounds for the indigenous Tonga, Ila and Batwa people of the Kafue Floodplain area (CSO 2006). On the other hand, even if the legal mesh sizes/gear in this fishery are: multi-filament gillnets of 3.0 inches (76mm) and above; monofilament nets of mesh size not less than 4.75 inches (120 mm); no use of seine or drag net of any kind; the survey data showed that every perceived fishing gear/net capable of catching the much needed fish is used on this fishery in one way or the other (CSO 2006).

Another challenge associated with open-access fisheries such as the Kafue floodplain fishery is control of immigrant fishers (Haller and Merten 2008). During the survey, the researcher noticed that there were a lot of immigrant fishers in some of the four fishing villages surveyed more especially in Chanyanya. The migrant fishers are often violent and control the fishing grounds and distribution channels (Haller and Merten 2008). Cormier-Salem (1994) observed that the resident fisher-folk (members of a local community) are well equipped in the management of common pool resources than the immigrant fishers. In compromise of Lake Tanganyika, most fisheries of Zambia are occupied by large numbers of small-scale fishers, rather than a few highly organized units. Most of the fishing is carried out by individuals with one or two helpers. In the Kafue floodplain to be specific, fishing was until recently not been a full time occupation; many fishers tend to revert to crop growing in the rain season (Haller and Merten 2008). Currently, many fishers still use dugout canoes and live in temporal structures in the fishing camps which are also used as permanent homes, raising families with little or no sanitation facilities (Haller and Merten 2008). In contrast, these small-scale fishers persistently do not adhere to State sanctions, for example during the fish ban period or when there is an outbreak of fish disease (Kapasa 2004).

2.5.1 Impact of Dams on Floodplain Fisheries

In spite of the significant values and functions provided by the floodplains, several of them have been degraded due to dam construction within their catchments. According to Thomas (1995), dams are a natural impediment to the movement of fish species. Thomas (1995) noted that dams often cause changes in temperature and river-flow, habitat loss, blockage of channels, abundance of planktons and alterations in silt-loading. These changes in turn affect fisheries (Thomas 1995). The most notable effect of dams on rivers with widespread floodplains is the decrease in the flooded area. This is exactly the case of the Kafue floodplain fishery affected by the Kafue Gorge and the Itezhi-tezhi Dams (FAO 2006). Likewise, breeding and nursery areas for fish have been reduced by dams in Africa and Zambia in particular. Moreover, fluctuations in floods are a barrier to lateral migration of fish species (Thomas 1995). Reduced flooding also means less permanent water persisting through the dry season and as such permanent fisher-folk are projected to be hard-hit.

2.6 Fundamental role of small-scale fisheries in poverty research

Prior studies have repeatedly focused on the fisher-folk resource dependence and the open-access nature of fisheries as explanations for resource degradation, poverty and marginalization (Allison and Ellis 2001). In literature concerning small-scale fisheries in low-income countries such as Zambia, the fisher-folk are often closely linked to poverty and have been characterized as the poorest of the poor (Béné 2003). However, reasons for poverty are increasingly seen to be caused by numerous factors and dimensions in fishery communities as in other rural communities, and not purely related to resource depletion (Béné 2003). Extreme poverty exists mainly in fishing communities where little amounts of fish is caught and traded, and where poverty is rather related to socio-institutional constraints (Béné 2006). Rural communities are not merely a burden on the national economies but also contribute to the Gross Domestic Product (GDP) through smallholder fishing activities (Béné 2006). Swanepoel and De Beer (2012) argued that apart from the large concentration of population in rural areas, there is also a problem of rural poverty which is endemic in rural areas. Swanepoel and De Beer (2012) further observed that it is mostly in rural areas where cases of malnutrition, hunger, and disease are more pronounced. Therefore, if you want to grow the economy, rural communities are a must (Swanepoel and De Beer 2012). Even though accessibility to public services and income levels maybe similar to other rural households, fishery households are prone to a very high level of vulnerability, due to the nature of fishing as a more risky occupation than most other occupations in rural communities (Béné 2004). Nevertheless, although small-scale fishery households are considered predominantly vulnerable, they too can be *less vulnerable* than other rural households because the fishery resources are certainly open to everyone (Tragedy of the Commons); and can thus function as a safety net for the poorest as well as for the more wealthy who experience an impulsive decrease in income due to various reasons (Béné 2004).

Furthermore, the role of small-scale fisheries in connection with an enhancement of livelihood security can be elucidated through the concept of *poverty alleviation, which* comprises the two welfare mechanisms *poverty prevention* and *poverty reduction* (Béné 2006). Moreover, poverty prevention mechanisms contribute to preserve a minimum standard of living among people, reduce risks and function as a "safety-net". This prevents underprivileged people from dwindling deeper into poverty in periods where individual or collective crisis occur (Béné 2006). An example of this are the activities related to small-scale fisheries that are open to anyone in need. Through welfare mechanisms, marginalized households rely on fishery based activities as a safety-net when lack of access to other resources and livelihoods occur (ibid). The Kafue floodplain fishery has been seen to fulfil this role in periods where macro-economic trends have led to unemployment in urban locations of Zambia (Béné *et al.* 2007). Alternatively, *poverty reduction* denotes wealth generation and capital accumulation made by investments, for instance fisheries that complements elating people out of poverty. Béné (2006) added that this concept is more unambiguously described as a situation where people are substantially well-off over a certain period of time as result of investing and participating in economic activities. The two welfare mechanisms are problematic to combine as improved production in fisheries is commonly associated with more capital intensive gear (Béné 2006). However, this easily eliminates or reduces the participation of people with limited resources (ibid). Notwithstanding a considerable increase in the number of nets per fisherman in the inshore fishery of the Kafue floodplain including other fisheries of Zambia, the technology has remained primarily the same during the last few decades (Kolding *et al.* 2003)

2.7 Climate Change and Variability

Post Note (2012) defined climate as a statistical summary of all the weather that occurs at a certain location over a relatively long period (30 years is often used). Therefore, long-term averages of weather conditions define the climate of a given area (Post Note 2012). Climatic elements include temperature, rainfall, wind and humidity among others. Additionally, IPCC (2007a) noted that the natural ecosystems on which human economies and cultures depend are largely influenced by climate patterns. "Climate change" does not only affect a change in the weather but also comprehends the seasonal changes of a particular area over a long period of time (IPCC 2007b). The IPCC (2007b) defined climate change as “change in the state of the climate identified (using statistical test) by changes in mean and/or variability of its properties”. These changes usually persist for a prolonged period of time usually decades or longer (IPCC 2007b; Seo *et al* 2013). Climate variability goes hand in hand with climate change. Climate variability generally denotes “changes in the mean state and other climate statistics (standard deviations, the occurrence of extremes and many others) on all temporal and spatial scales outside individual weather events” (IPCC 2007b). The degree of climate variability is often described as the variation in long-term statistics of the weather elements calculated for different time periods (Post Note 2012).

2.8 Climate Change and Fisheries

Climate change is extensively anticipated to affect ecosystems, societies and economies (FAO 2009a). This will mount pressure on livelihoods and food supplies more especially for individuals involved in fisheries and aquaculture sectors. FAO (2009a) noted that accessibility and availability of fish supplies will increasingly be under greater pressure due to climate variability. For instance, Clark (2006) observed that there will be changes in fish distribution patterns owing to intensified sea surface temperatures around South Africa. Thus, large numbers of tropical fish species will infest waters off Southern Africa while stronger upwelling cells may restrict fish species in the temperate latitudes (FAO 2009a). Brander (2010) noted that climate change impacts on fish stocks through direct and indirect means. Direct impacts of climate change alter growth, reproductive capacity, mortality and distribution of fish's physiology and behaviour. According to Brander (2010), the food security of the marine ecosystems are indirectly altered through productivity, structure and composition. Biological fishing interactions and non-climatic environmental factors are among other factors affected by climatic stresses (Brander 2010). Intensification of biophysical factors as result of climate change affects fish ecology in many fisheries of the world (FAO 2009a). Over-exploitation, changes in markets, loss of habitat, pollution, species infestation, water abstraction and damming are among the many other stresses that the world's fisheries production systems already experience apart from climate change effect (Delgado and Abbate 2013).

Nevertheless, Delgado and Abbate (2013) noted that increased economic hardships are experienced amongst countries that lack the capacity to adapt to large scale climatic changes in fisheries. This is so because of the uncertainty in the trends of climate change effects on the biophysical processes especially for particular fisheries (Allison *et al*. 2009). As a result of climatic stresses, some countries may experience improvements in fishing opportunities while other countries may experience detrimental climatic effects on fisheries (Allison *et al.* 2009). It is usually very difficult for most countries to transform enhanced fishery efficiency into reduced poverty due to weak economies and poor governance (Allison *et al*, 2009). Hence, building adaptive capacity is a necessary response to climate shocks (Allison *et al.* 2009). Notably, utmost adaptation measures for climate change in different countries are in line with the intentions of strengthening livelihoods and environmental governance through reductions in poverty and overfishing (Allison *et al.* 2009). In addition, Brander (2010) further noted that it is very important to comprehend both long and short term climate variability in order to predict future climate impacts on marine ecosystems and fisheries. In recent years, there has been substantiated evidence on how climate change affects distribution, production and seasonality of marine and freshwater fisheries (Brander 2010) . For instance, between 1997 and 2003, there was a 50% increase in global aquaculture production and almost a 5% decrease in capture productions. Brander (2010) pointed that the above mentioned trends in climate change will continue to affect fisheries production.

2.9 Vulnerability of the small-scale fisher-folk

Climate variations and severe events like hurricanes and floods have always affected fisheries (FAO 2009a). Vulnerability has until recently become an important concept in climate change literature. FAO (2009a) defines vulnerability as "the susceptibility of groups or individuals to harm as a result of climatic changes". According to the WGII (2014), vulnerability to climate change results from social, economic, cultural, political and institutional dimensions that entrench human lives. Hence, vulnerability is hardly due to a single source, rather, it involves intersecting social processes such as inequalities in income levels and exposure (WGII 2014). For example, discrimination on gender basis is rampant in fisheries because fishing is mostly a male-dominated activity hence the women are solely not active in this industry (WGII 2014). Consequently, the vulnerability of fisheries and fishing communities is not only dependent on the sensitivity and exposure of individuals to change but also on their adaptive capacity (WGII 2014). FAO (2009a) noted that tropical regions in the developing countries are more susceptible to climate change vulnerabilities because of their reduced adaptive capacity.

2.10 Potential Impacts of climate variability on fisheries

Climate variability can impact economies, coastal communities and fisheries through multiple ways. Significantly, marine and freshwater ecosystems are influenced by slight changes in water temperature, precipitation and wind velocity (Islam *et al*. 2014). The changes in ecological, biological and fish population in such ecosystems directly impact on the livelihoods of the people. For instance, light intensity and temperature affect the amount of nutrients in a river/lake which in turn impact on primary productivity (FAO 2008). Similarly, decrease in rainfall amounts in certain areas reduces the amount of run-off from land. This usually degrades wetlands and eventually damages the local fisheries (FAO 2008). In other areas, increased precipitation or flooding washes away sewage and fertilizer into water bodies thereby breeding red tides (Roessig *et al*. 2004). These red tides are harmful algal blooms which may destroy certain fish species in rivers and lakes (Epstein 2000). Moreover, Westlund (2007) indicated that fishing tasks and land-based infrastructure may at times be disrupted by extreme weather events. Further, Islam *et al*. (2014) stated that variations in fishery production affects livelihood strategies of the small scale fisher-folk especially those living in seaward communities. The rise in sea level, increase in storm intensity and frequency usually cause damage to property and infrastructure of the small scale fisher-folk (FAO 2009b). Additionally, fishing practices based on tacit knowledge of local weather systems are disrupted by extreme change in weather patterns while worsening storms often increase the risk of fisher-folk working at sea (FAO 2009b). Climate change impacts on fishing activities can have ecological, direct and socio-economic effects on the livelihoods of the small scale fishing communities as shown in figure 2.6 below.

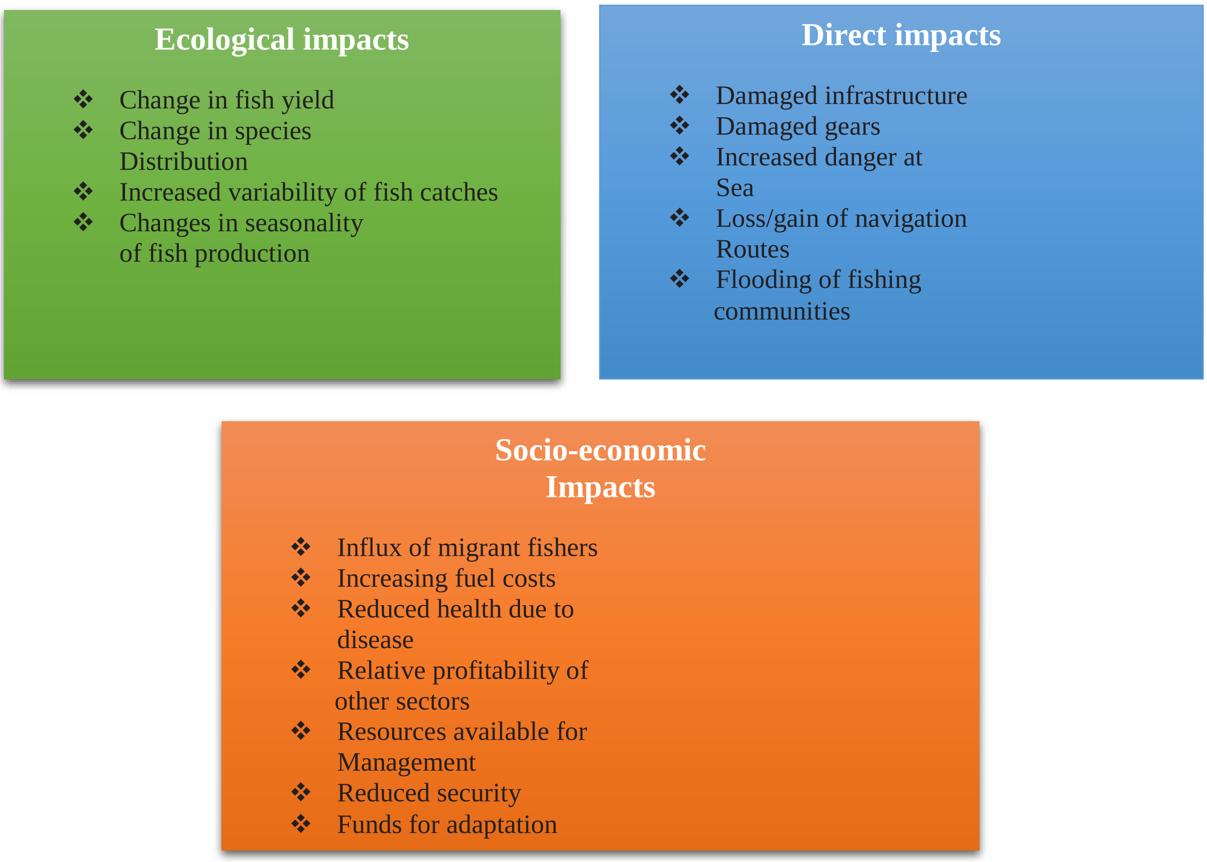

Figure 2.6 : Examples of potential direct, social-economic and ecological impacts of climate variability on fisheries

Source: FAO (2009a)

2.11 Impacts of Climate Variability and Change on Livelihoods Assets

2.11.1 Changes in natural capital

Changing resource scarcity or unpredictability due to climate change will undoubtedly impact on communities heavily reliant on fisheries as a major livelihood (FAO 2009a). According to Delgado and Abbate (2013), variations in the accessibility of natural capital that is fish products often affects total income and harvesting costs. Consequently, there are greater costs in the management and accessibility of natural capital resulting from the net revenues (Badjeck *et al.* 2010). Sea-level rise, land erosion, and variations in temperature and rainfall usually weaken land-based assets (Islam *et al.* 2014). Islam *et al.* (2014) stated that these impacts often affect fishery-dependent livelihoods. Therefore, declines in fish stock richness and successively fish catches are a consequence of climate variability and change arising from reduced net revenue. For example, Islam *et al*. (2014) noted that there was a density reduction of 80% in the amount of Caribbean coral cover in 1970 as a result of extreme hurricanes and high sea surface temperatures. Additionally, climate-related disease outbreaks were experienced in the Caribbean basin due to the frequent and more severe hurricanes (Burke and Maidens (2004); Islam *et al*. (2014). Coral cover greatly affects the diversity and abundance of fish in different regions of the world and is also influenced by climate change shocks. Alvarez-Filip *et al*. (2009) stated that there will be an annual fish production decline of about 30-40% by the year 2015 in the Caribbean region due to coral cover reductions resulting from climatic effects. Badjeck *et al*. (2010) observed that in Peru, pelagic fisheries species were also affected with 55% loss of revenues in different years. Similarly, Brander (2007) observed shifts in distribution patterns of algae, plankton and fish species in North East Atlantic affected fish stocks. Moreover, IPCC (2007a) also noted movement of plankton species of at least 1100 km northwards in just 40 years may have affected primary productivity. Additionally, fish stocks and primary productivity had drastically reduced in Lake Tanganyika by 20% and 30% respectively (Brander 2007; FAO 2007; World Fish Center 2007).

2.11.2 Damage to physical capital and reduced financial capital

According to Badjeck *et al.* (2010), the rise in sea-level, increase in storm intensity and variations in flood occurrences affect the physical capital of fisheries in different regions of the world. The harvesting capacity of most fishing households is disrupted when livelihood support services and public infrastructure decline (Badjeck *et al*. 2010). Further, Jallow *et al*. (1999) stated that landing sites, boats and fishing gear are severely damaged specifically during storm and extreme climate events. For instance, Aiken *et al.* (1992) reported that 90% of the fisher-folk in Jamaica lost their fishing traps during Hurricane Gilbert in 1998. This resulted in income loss and increased cost of repairs in order to promptly resume fishing activities (Aiken *et al.* 1992). Westlund (2007) also noted that extreme climate events also destroy fisher-folk' non-productive assets such as hospitals, schools, sewage systems and many others. For instance, El Niño destroyed a number of houses for the majority of the fisher-folk in Northern Peru (Westlund 2007).

2.11.3 Impacts on human capital and social capital

FAO (2009a) observed restricted mobility will constrain small scale fishers once shifts in distribution patterns of fish species respond to climate change. Loss or repositioning of local resources will indisputably stress institutions of traditional area-based access rights (FAO 2009a). Even though certain fishers will realise the extinction of their target species, others will perhaps comprehend an upsurge in landing of highly profitable species (FAO 2009a). For example, El Niño years experienced an increase in shrimp and octopus landings in Northern Peru (FAO 2009a). Similarly, rise in scallops landing were also noticed in south of Peru when tropical waters warmed up (FAO 2009b). Subsequently, international markets have been established because these species are of high commercial value than the indigenous (Badjeck 2008).

Climate variability and change also affects both safety-at-sea and food security. Westlund (2007) noted that the loss of life is the most risky climatic effect on human capital. This potentially disrupts the economic and social activities of surviving household members and other the immediate families (Westlund 2007). Floods and hurricanes are the climatic stresses associated with safety at sea and injuries (Westlund 2007). The fisher-folk' physical capabilities to pursue their livelihoods are often reduced by such stresses. In terms of health effects, malaria is extremely susceptive to El Niño (Badjeck *et al.* 2010). For instance, Badjeck *et al*. (2010) observed that the small-scale fisher-folk in South America, Central Asia, and Africa were largely affected by Malaria. Changes in food accessibility and affordability as a result of climatic disturbances constitute an additional health problem for the majority of households and communities world over. For instance, Ogutu-Ohwayo *et al.* (1997) noted a high threat of starvation and nutritional loss for communities critically dependent on fish. This can be alluded to the decrease in fish catches as result of climate change events; particularly for countries with the greatest dependence on the nutritional value of fish such as Asia and sub-Saharan-Africa (Delgado and Abbate 2013). Furthermore, Badjeck *et al*. (2010) stated that infrastructure damages resulting from extreme events such as flooding may reduce access to local markets thereby diminishing food product availability and increasing market prices. Additionally, local institutions providing the foundation of resource management, specifically property rights can also be affected by variability in climate (Badjeck *et al*. 2010). At the local scale, property rights and resource access conflicts could arise from fluctuations in richness, form and shifts of fisheries stock (Conway *et al.* 2005). In Southern Africa, increasing drought frequencies affected the livelihoods of the fishing communities living along the lakeshore and river floodplains (Conway *et al*. 2005).

2.12 Conceptual Framework

The study is conceived on the premise that climate change affects fisheries in direct and indirect pathways depending on the type of ecosystem and fishery. Badjeck *et al*. (2010) stated that climate variability (through changes in: rainfall pattern, wind pattern, temperature, lake levels, occurrence of storms, increased flooding event and drought among others) impacts Inland fisheries where the majority of small scale fishers are found through different ways. Badjeck *et al.* (2010) further observed that production ecology, fishing operations, safety and efficiency of fishing infrastructure are usually affected by climatic changes as shown in figure 2.7 below. These climatic changes influence fish species composition, production and yield, risk of health and life of the fisher folk as well as loss and damage to livelihood assets thereby impacting on the fisher-folk livelihood strategies (Badjeck *et al*. 2010). Henceforth, the fisher folk needs to devise adaptation and mitigation strategies in order to sustain their livelihood.

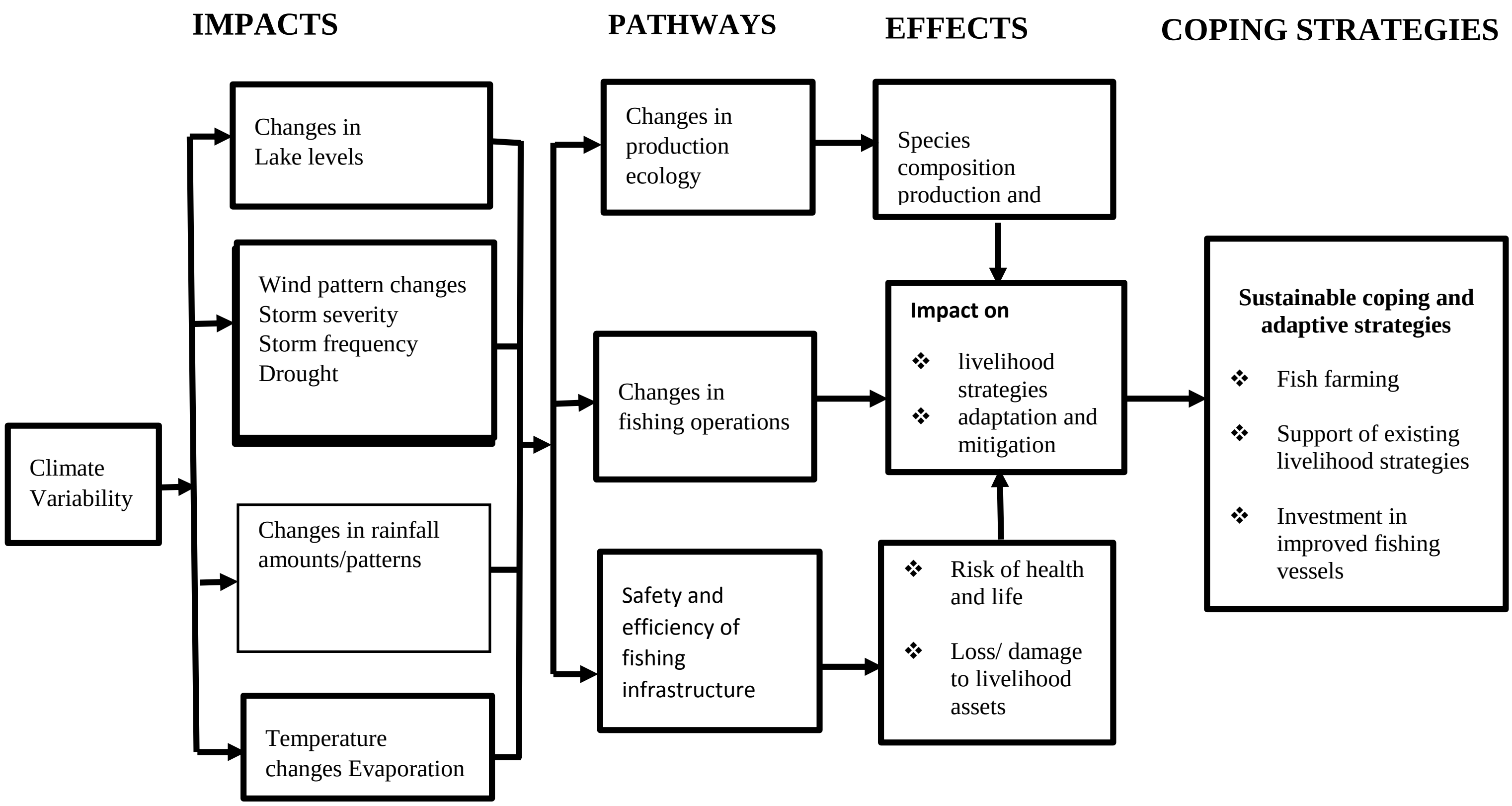

Figure 2.7 : The Conceptual Model for the Implications of climate variability on small scale fishing activities and Fishers adaptive capacity

Source: Adapted and Modified from Badjeck *et al.* (2010) .

2.13 Chapter Summary

The literature reviewed indicates that small scale fisheries considerably contribute to nutrition, food security, alleviation of poverty and sustainable livelihoods especially in developing countries such as Zambia. Every year, the Department of Fisheries in Zambia implements the fish ban in order to allow fish to increase in quantity, grow and breed in the restricted fishery areas. The literature reviewed points out that a huge number of the fisher-folk in Zambia are artisanal utilizing traditional fishing methods such as dug-out canoes, gill nets, baskets and traps. Although fishing communities are generally known to be poor; poverty in fishery communities is not purely related to resource depletion but rather to socio-institutional constraints. Furthermore, fisheries are highly susceptible to climate change impacts through multiple ways. For instance; production ecology and fish yield, fishing operations, safety and efficiency of fishing infrastructure, health and life of the fisher folk as well as loss and damage to livelihood assets are undoubtedly affected by climatic changes. Notably, vulnerability to climate change is mainly pronounced in tropical regions of developing countries due to reduced adaptive capacity. Above and beyond, climate variability and change affects fisheries activities, mounts pressure on food and livelihood assets. Therefore, the fisher-folk needs to devise adaptation and mitigation strategies in order to sustain their livelihood.

The next chapter gives a description of the study area and also discusses the methodology employed in collecting data required for this study.

CHAPTER 3 : METHODOLOGY AND DESCRIPTION OF THE STUDY AREA

3.1 Introduction

This chapter gives a general description of the study area including both the biophysical and socio-economic characteristics of the study area and the surrounding communities. The chapter further outlines the study methodology employed through a sampling design, sample size and sampling procedure including questionnaire administration. Additionally, data collection techniques and processing as well as analysis procedures are also presented in this chapter.

3.2 Location

The Kafue Flats floodplain is situated mainly in the Southern Province of Zambia between latitudes 15°20'-15°55' south of the equator and longitudes 26°-28° east of Greenwich (DoF 2011). Kafue floodplain fishery is about 440Km long from Itezhi-tezhi dam to Kafue Gorge dam where hydro-electricity is generated (CSO 2006). The Kafue Flats are situated alongside the Kafue River, a core tributary of the Zambezi River which flows through Copperbelt, Central, Southern and Lusaka Provinces (CSO 2006). The Kafue River crosses lowland savannah swamps after leaving the Copper-belt Province as it flows southwards. The Kafue river covers an area of 6,500 square kilometres and then forms the floodplains known as the Kafue Flats (World Fish Center 2007). Additionally, the Kafue flats are located 50 km north east of Lusaka town and at the eastern end of the floodplain closer to Kafue district (DoF 2011). Kafue district covers a total area of 9,045km^2 with a total population of 242, 754 (CSO 2011). The Kafue Flats are among the most biologically diverse ecosystems in Zambia comprising of multifaceted patterns of lagoon, marshes and floodplain grasslands (WWF-Zambia 2004). The Flats provide a habitat for a variety of wildlife and water fowl (Mumba and Thompson 2005). The Kafue Flats are a vast alluvial plain 440 km long and 60 km wide (Mumba and Thompson 2005). The Flats cover an area of nearly 6,500km^2 between Itezhi-tezhi dam and the Kafue Gorge dam (Mumba and Thompson 2005). As a result of its shallow gradient (6 m from Itezhi-tezhi to the impounding reservoir surface elevation of Kafue Gorge), the Flats are characterised by floodplain swamps and marshlands (Mumba and Thompson 2005).

Moreover, the extensive floodplains of the Kafue River stretches along five districts of Southern Province, namely; Mazabuka, Monze, Itezhi-tezhi and Namwala and part of Kafue district in Lusaka Province (DoF 2011). According to DoF (2011), the Kafue floodplain fishery has seven (major) lagoons namely Lukwato, Namwala, Kabulungwe, Chunga, Luwato, Chanyanya and Chansi. These lagoons are considered potential fish breeding areas based on the size and number of fish caught (DoF 2011). The floodplain supports a wetland ecosystem of exceptional productivity because of periodic inundation (DoF 2011). According to DoF (2011), the Kafue flood plain fishery is regulated through the four different strata or administrative units as follows:

- Stratum I: extends from Kafue Gorge to Chanyanya Lagoon and includes 27 villages;
- Stratum II: from Chanyanya Lagoon to Chunga Lagoon (Lochinvar) and includes 61 villages;
- Stratum III : from Chunga Lagoon to Namwala and includes 47 villages;
- Stratum IV: administered from Namwala, extends from Namwala to Itezhi-tezhi dam and includes 34 villages.

The Department of Fisheries (DoF) in Kafue district is responsible for the Kafue Fisheries from Cheeba Fishing Camp at Kafue Gorge to Nanga in Mazabuka District (DoF 2011). Although there are 26 fishing camps accommodating 400 fishers of which 191 are fully registered, the only permanent fishing camps in Kafue district are Cheeba and Chanyanya (DoF 2011). Traditionally the district is divided into 3 chiefdoms, Chief Chiyaba, Chieftainess Nkomesha and Chieftaines Mwenda.

3.3 Climate

3.3.1 Seasonal variations

The main seasons experienced in the Kafue flats are summer and winter (ADB 2013). This is to say that the Kafue Flats have tropical and sub-tropical climate (ADB 2013). The rainy season which corresponds to summer proceeds from November to April annually (ADB 2013). While winter corresponding to the dry season runs from May to October/November(ADB 2013). ADB (2013) observed that the dry season is divided into two seasons; the cool and dry season runs from May to August while the warm and dry season proceeds from September to October. According to WWF-Zambia (2004), the Kafue flats ecosystem has been severely influenced by series of floods and droughts. For instance, the flash floods of the 2005/2006 rainy season disrupted power generation at the Kafue Gorge Power Station in December 2005 for a period of two weeks (ADB 2013). Similarly, agricultural fields and houses in Mazabuka, Choma and Monze were extensively affected by the 2006 floods during the months of February and March (ADB 2013).

3.3.2 Rainfall patterns

Rainfall in the Kafue Flats is essentially brought about by convergence of the Trade Winds well-known as the Inter Tropical Convergence Zone (ITCZ). The variation in annual rainfall ranges from 1,300mm in the north to 800mm in the south (Ramser 2003). The southern and western areas of the Kafue Flats have more pronounced natural variations in rainfall due to the frequency and extent of dry spells. This results from the inter-annual fluctuations in the southern extent of the ITCZ (ADB 2013). Annual rainfall of less than 800 mm is received in Zone I in the south whereas Zone II (in the centre) where this study was conducted receives annual rainfall between 800-1200 mm (ADB 2013). Notably, annual rainfall of more than 1 200 mm is received in Zone III in the northern part of Zambia.

3.3.3 Temperature

The Kafue Sub-basin normally has warm temperatures though cooler than in the rift valley areas (ADB 2013). ADB (2013) noted that temperature variations in the Kafue basin basically result from changes in altitude. For example, areas such as Namwala, Kafue Flats and Itezhi-tezhi are highly elevated than lowland valley areas. In general, there are changes in the mean monthly temperatures i.e. 14 ºC in June/July and 27.5 ºC in October (ADB 2013). Overall, there are variations in mean maximum and minimum temperatures in the Kafue Flats. In October, mean maximum temperatures vary from 16 ºC to 34 ºC while the mean minimum temperatures fluctuate from 7 ºC to 24 ºC in July (ADB 2013) .

3.4 Topography, Geology and Soils

3.4.1 Topography

The Kafue flats lie at an altitude of about 1,000 - 1,200m and are part of the central African plateau (ADB 2013). According to ADB (2013), the landscape of the Kafue Sub-basin is undulating with gently sloping terrain forming landforms towards the plains. In general, enormous contours of grasslands often inundate the open Miombo forests (ADB 2013).

3.4.2 Geology

The Kafue Sub-basin geology is made up of complicated sediments of the Katanga emanating from the late Precambrian age. It is one of the representations of the prehistoric landmasses in Africa (ADB 2013).

3.4.3 Soils

The Kafue flats comprise of diverse types of soils such as deep dark (Montimorillonite) and heavy alluvial clays. The parent material, geomorphology, and rate of weathering interact to form these soils (ADB 2013). The montimorillonite soils hold large quantities of water and are dark because of the affluent carbon content. These soils generally hydrate when wet and dehydrate when dry (ADB 2013).

3.5 Biodiversity (Flora and Fauna)

3.5.1 Flora

As a biologically diverse ecosystem, the Kafue Flats comprise of the meandering Kafue River, ox-bow lakes, a complex pattern of lagoons, abandoned river channels, marshes, levees and floodplain grassland (ADB 2013). According to ADB (2013), the flooding regime and the soil determine the zoning of vegetation in the Kafue Flats. Woodland savannah (predominantly known as munga/acacia), termitaria grasslands, permanent swamps (reeds and papyrus) and floodplain grasses/sedges are the main vegetation types found in the Kafue Flats (ADB 2013). The Kafue eco-region also has terrestrial vegetation which is a diverse mosaic of miombo ("*Brachystegia/Julbernardia*"), "*Acacia/Combretum*" and mopane woodland, and grasslands dominated by rice grass ("*Oryza barthii*"), "*Echinochloa pyramidalis*", "*Vetivaria nigritana*", "*Acroceras macrum*", and "*Setaria avettae*" (ADB 2013). The extent of the floodplain inundated by floodwaters and the annual cycle of flooding and drought exert a profound effect on fish productivity in the Kafue Flats (Chapman *et al*. 1971). Aquatic grasses and other vegetation grow rapidly following the advent of the floods during the rainy season and most fish species reproduce around this period, so the resultant young fish have access to food and shelter (ADB 2013).

3.5.2 Fauna

ADB (2013) indicated that the Kafue Flats provide a home to a wide range of birds and animals as well as rare species. There are over 400 bird species in the Kafue flats including 125 waterbirds and the endangered wattled crane (ADB 2013). The Kafue flats contains a large number of grazing mammals such as Hippopotamus, zebra, sitatunga and buffalo (ADB 2013). Cheetah and wild dogs are the main predators found in the Kafue Flats. ADB (2013) further noted that the Kafue flats also provide a habit for an endemic antelope known as Kafue Lechwe (*Kobus leche*), which is especially adapted to life in marshes.

Figure 3.1 : Map of Zambia in Africa.

Source: Generated by Ingrid Boysen, 2014.

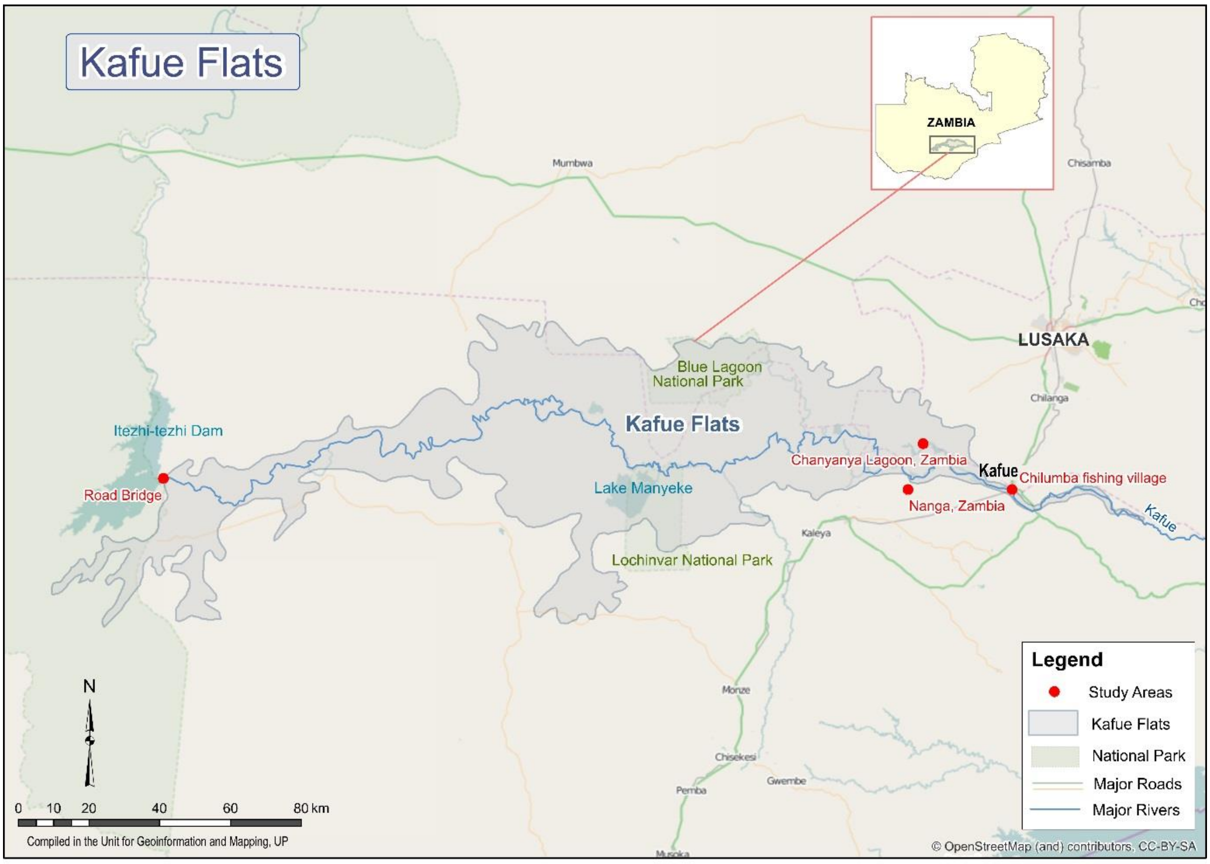

Figure 3.2 : Study areas covered in stratum I (Kafue district) of the Kafue floodplain fishery.

Source: Generated by Ingrid Boysen, 2014.

3.6 Population characteristics

Population densities are low in Kafue district and currently a total population of 242, 754 people reside in the district (DoF 2011). The communities in Kafue district are generally small and are more concentrated along roads, lake edges and rivers (DoF 2011) . Fishing is a key activity in the Kafue Flats and mainly takes place in March to November due to an annual 'fishing ban' proceeding from December to February (DoF 2011).

3.7 Ethnicity

The Kafue Flats have a huge number of ethnic groups such as the Tonga, Ila, Batwa and Balundwe people. For centuries, these people have mostly practiced fishing and small-scale agriculture (CSO 2006). The CSO (2006) fishery report indicated that the earliest settlers in the Kafue Flats are the Tonga speaking people. However, the Bemba and Lozi from Western and Northern provinces of Zambia together with people from Zimbabwe and Democratic

Republic of Congo moved to the Kafue Flats in search of settlement and employment (CSO 2006). The Kafue have witnessed an upsurge in fishing and trading activities in the Kafue Flats since the migration of the Bemba and Lozi people (CSO 2006).

3.8 Economic Activities

The Kafue flats are an important area for fishing, sugar cane farming, hydro power production, cattle and grazing (ADB 2013). Zambia's water resources have a greater potential for hydro power production significant to the country's economy and the economy of the entire Southern African region (ADB 2013). The Kafue Gorge hydroelectric power plant located at the eastern end of the Kafue Flats is largest power station in Zambia providing at least 50% of the country's electricity needs (ADB 2013). Traditionally, fishing and livestock grazing are the main sources of livelihood for the majority of people in the Kafue Flats (ADB 2013). The Kafue flats support an enormous fishery which is predominantly based on the productivity of the floodplain (ADB 2013). Fishing takes place continuously throughout the annual water cycle on the Kafue Flats with most fishing accomplished from canoes fishing (Ramser 2003). In the course of floods, fish moves onto the floodplain where most spawning and growth takes place (ADB 2013). ADB (2013) noted that villages along the river banks are frequently inundated during high water and are evacuated. Additionally, the fisher-folk use gill-nets and often operate from the small villages or fishing camps situated around the margins of the floodplain during the high water periods (ADB 2013). ADB (2013) observed that several cichlids *(Sartherodon* spp. and others) and barbels *(Clarias* spp.) are the primary species caught within the Kafue Flats flood plain fishery.

On the other hand, Ramser (2003) observed that a large part of the Kafue floodplain dries up during the dry season releasing chemical nutrients. The chemical nutrients often result from burning, decomposition of biota and from the faeces of domestic cattle and antelopes which principally invade the area to graze. Furthermore, several sugarcane farms located south-east of the Kafue Flats near Mazabuka town produce most of Zambia's sugar (CSO 2006). The sugar produced from these huge cultivated farms is used locally and also exported to neighbouring countries. However, the CSO (2006) indicated that many areas of the Kafue Flats have very poor transport infrastructure. Hence, this results in geographical isolation of the local people thereby having difficulties in basic service such as health and education. In this case, the government through the Department of Fisheries has formally categorised certain fishing villages/camps in the Kafue Flats as 'hard-to-reach' areas (CSO 2006).

The next section outlines the methodology employed in this study

3.9 Methodology

This study utilised both quantitative and qualitative methods of data collection. This enabled triangulation of findings thereby providing consistent data in understanding the climatic factors affecting the fishing and livelihoods activities of the fisher-folk in the Kafue Floodplain Fishery. This research methodology permitted the use of different practices and techniques to gather processes in order to manipulate information that can be used to test ideas and theories about social life. Henceforth, it was a systematic way of solving the research problem (Goddard and Melville 2004).

3.9.1 Research Design

This study adopted mixed methods approach (known as methodological triangulation) because the objectives demanded for qualitative and quantitative data. Methodological triangulation involves consulting multiple sources of data, use of different methodologies in combination and employing expert judgment (Creswell 2013). Sanginga and Chitsike (2005) noted that triangulation combines both quantitative and qualitative approaches and is one of the guiding principles of participatory approaches. According to Creswell (2013); Creswell (2003), mixed methods approach enables comparison of different perspectives drawn from quantitative and qualitative data, in order to understand the phenomenon of interest in-depth and to produce well validated conclusions. Since every research tool or method has limitations, the triangulation or mixed methods approach was appropriate for this study because the approach entirely allows for different methodological perspectives to reinforce each other, resulting in a holistic approach compensating for the weaknesses within any single method (Flick (2009); Creswell (2013). The qualitative approach was appropriate for this study because of its potential to considerably draw on social relations (Flick 2009). According to Bruyere *et al*. (2009) qualitative approaches help to convey in-depth information and understanding of the context, processes and implementation dynamics of a study. Bruyere *et al.* (2009) further noted that a qualitative approach also considers the social and cultural norms that require that relationships be built before asking personal information. In this study, qualitative data helped to verify and enrich the quantitative data that was obtained from the questionnaire (Mehta and Kellert 1998). This study was also quantitative in nature. The quantitative approach permitted statistical inferences to be made on the data collected from the structured questionnaires (Sandelowski 2000). The study questionnaire surveys (Appendix I), key informant interviews

(Appendix II, III and IV) and group discussions were used to gather related data from various stakeholders. Fishing village surveys, observations and review of secondary data were conducted to gather complementary information and to check the validity of the study findings. Henceforward, a skillful combination of several alternative methods and information sources was necessary.

Moreover, issues handled in this study are complex and span across several disciplines and sub-disciplines such as climate change and fisheries, aquaculture, small scale fisheries (artisanal fishing), human vulnerabilities and livelihoods, sustainable livelihoods, ecology, agriculture, marketing, tourism, nature conservation, water resources management, fisheries co-management and international trade and relations. Thus a single study cannot expect to fully address the many questions and sub-questions arising henceforward. Conversely, Pretty (2011) noted that the importance of new engagements between different knowledge bases is gaining increasing recognition among scientific institutions (Pretty 2011). Likewise, Cummings and Kiesler (2005); Acevedo (2011) observed that interdisciplinary work provides many opportunities for synergies in research and extension even though numerous studies reveal the difficulties and costs in conducting interdisciplinary research. Henceforth, by adopting an interdisciplinary approach the present work hopes to draw the various disciplines closer or, at least, to draw attention to the value of their inter-linkages.

3.9.2 Types of Data

To examine the implications of climate variability on fishing activities and the adaptive strategies of the small scale fishing communities in the Kafue Flats within Kafue district, the research utilised both primary and secondary sources of data. Primary data was collected from the field work using snowball and purposive sampling techniques while secondary data was obtained from documentary sources.

Table 3.1 : Nature and Types of Data Collected.

Data collected	Nature of data	Variables used	Methods of analysis
Climate variability(Changes in Rainfall, Temperature and Wind)	Primary and Secondary	Average changes in temperature, rainfall and wind between 1982- 2012	Quantitative using SPSS, ANCLIM and TREND Software's to analyse means or averages, statistical significance and magnitude of trends from the recorded measurements
Implications of climate variability on the fishing activities and fishing duration.	Primary	The responses will be based on structured questionnaire	Mixed Methods (use of questionnaire and Interview guide)
Effects of climate variability on fish catch	Primary	Average changes in rainfall, temperature and wind during different seasons and the amount of fish catch during the different seasons over the period 1982-2012	Quantitative using SPSS to analyse averages and percentages based on the recorded measurements of weather element and the amount of fish catch
Effects of climate variability on the choice of fishing techniques/gear	Primary and Secondary	Average changes in rainfall, temperature and wind and effects of these changes on the choice of fishing techniques or gear	Mixed Methods (based on the percentage changes in techniques and qualitative analysis based on the explanation from discussions and interview guide on the reasons for changes).

Periodic variation in the size of Kafue Flats	Secondary	Average changes in the size (km^2) based on the satellite images for the period 1982-2012 from the NRSC	Change detection analysis of the satellite images using ARC GIS 10.1 and ENV 4.8
Adaptive strategies	Primary	The different sources of livelihoods apart from fishing(for example, farming, boat repairing and many others)	Mixed Methods (use of questionnaire and interview guide)

Source: Field work data, 2014.

3.9.3 Sample Frame

The closeness of the Kafue floodplain fishery to Lusaka City makes it very attractive to fish traders. Thus, location, economy, scale of fishing activities and proximity to basic services were some of the factors considered in the selection criteria. The respondents comprised of three categories namely the fisher-folk, selected traditional leaders and officials from Fisheries and Meteorological Departments. The fisher folk were drawn from the villages within the Kafue Flats using Snowball sampling technique.

3.9.4 Sample Size and Sampling Procedure

The sample size comprised of 110 fisher-folk (respondents) with similar characteristics as part of the target population under study (Oso and Onen 2005). The Kafue Flats cover the different districts within Southern province of Zambia namely Kafue, Namwala, Monze, Mazabuka and Itezhi tezhi. Kafue district lies within Stratum I of the four strata that form the Kafue flood plain fishery namely Stratum I, II, III and IV (DoF 2011). The fishing camps in Kafue district are spread across two chiefdoms, Nkomesha and Chayaba (DoF 2011). The study population consisted of persons living along the Kafue River and dependent on fishing for their livelihood or involved in fishing activities from Road Bridge, Chanyanya until Nanga fishing villages within Kafue district. According to Creswell (2013), statistical analyses require at least a minimum sample size of 30 as a suitable rule of thumb. Saunders *et al.* (2012) also points out that a sample size of 30 or more normally results in a sampling distribution where the mean is very close to a normal distribution. Moreover,Creswell (2013) noted that a study sample size must be large enough to reflect a generalized picture of the findings. To this regard, a sample size of 110 small scale fisher-folk was adequate and appropriate for this study. The aforementioned sample size was thus, representative of the population while the sampling distribution was very close to a normal distribution. The study sample was drawn from Chanyanya, Nanga, Road Bridge and Chilumba fishing villages/camps within the Kafue Flats using snowball sampling technique. This technique was used because not all people in the fishing villages are involved in small scale fishing as some of them are traders only. Although snowball sampling is not a systemized method for identifying research participants, it can, nonetheless, be very productive (Atikinson and Flint 2004). Snowball sampling procedure is useful for research samples especially in studies where existing themes recruit future themes from among their associates as is the case for this study (Li *et al*. 2010). This technique is also useful in cases where it is hard to establish a sampling frame (Li *et al.* 2010; Sadler *et al.* 2010; Ersoy *et al*. 2012). The selection process began with establishing contact with the Fisheries officials in Kafue district who identified one of the fishers within the Kafue Flats. The identified fisher-folk(s) then assisted in recruiting other potential respondents until the required sample size was attained. The key informants i.e. traditional leaders and officials from the Fisheries and Meteorological Departments were selected using non-probability purposive random sampling. The use of purposive random sampling in qualitative research improves understanding of information and removes biasness on the researcher thus providing a good representation of the target population (Patton 1990). Although very few, the key informants provided pertinent information related to the research from their areas of specialisation (Neuman 2005).

3.9.5 Data Collection Techniques

Information for primary and secondary data was collected from fieldwork and documentary sources respectively. Documentary sources included documents on annual fish production in the Kafue Floodplain Fishery within Kafue district, climate variability from the fisheries and the meteorological departments. Collection of data in the Kafue Flats within Kafue District was carried out between June and July, 2014. Prior to the actual collection of primary data, the researcher conducted a pilot study using a sample of the local people in the study area. The pilot study helped to improve the clarity of the research questions and as such some questions were modified after the pilot study. Ultimately, a reliable and valid research tool was obtained and the questions included were clear, understandable and yielded relevant information.

3.9.5.1 Primary Data

Primary data was collected from the field through interviews using three sets of tools namely a structured face - face - questionnaire, interview guides and observation record sheet over a seventeen (17) day period. Questionnaires are a systematic and scientific means of data collection in which a questionnaire was used on the fisher-folk to solicit their valuable responses. This study utilised face - to - face questionnaire because of its strength to eliminate non-responses from the respondents and its reliability for the authenticity of responses through direct observation (Tamuno and Smith 2008). The questionnaires were administered by way of interviewing the respondents in local dialects i.e. Bemba and Tonga as the majority of the respondents were disadvantaged with the use of English. This approach was advantageous in terms of precision and use of statistics thereby reducing to a great extent the risk of subjectivity inference in the study (Cramer 1998). Accordingly, the structured questionnaire (Appendix I) was self-administered to the fisher-folk while interview guides (Appendix II, III and IV) were used to gather information from key informants. The structured face - to - face questionnaire contained both closed-ended and open-ended questions. The closed-ended questions were used to solicit information from the respondents on matters such as demographic characteristics, economic activities, seasonal variations in the amount of fish catch, fishing duration as well as fishing techniques and equipment. Moreover, the open ended questions were used to gather information on the fisher-folk's own assessment of the impact of climate variability and the description of livelihood strategies. Additionally, the interviewees were encouraged to ask questions and contribute other points of view other than those mentioned by the interviewer. This combination of a formal and informal structure is characteristic of the semi-standardized interview, which allows the interviewer to digress, focus on particular interesting topics and make follow-up questions (Berg 1988). On the other hand, observations were made on various economic activities carried out in the study area and information was recorded on a record sheet. Besides, interview guides were used to collect information from selected traditional leaders and officials from Fisheries and Meteorological departments on various issues such as variability of climatic elements, fishing methods and other economic activities.

3.9.5.2 Secondary Data

Secondary data was obtained from published and unpublished reports such as weather, annual and research reports, topographic maps, satellite images, statistical reports on fish production and population of the fisher-folk. These reports were sourced from the Zambia Meteorological Department (ZMD) and National Remote Sensing Centre in Lusaka (NRSC), Department of

Fisheries in Kafue district, and Fisheries headquarters in Chilanga. Data on weather patterns (mean monthly rainfall and temperature) over the past 30 years (1982-2011) was obtained from the Zambian Meteorology Department based on maximum and minimum measurements for each month. Alternatively, data on the number of fisher-folk, amount of fish catch, fishing techniques/equipment and economic activities in the area was gotten from the Department of Fisheries in Kafue district and the Fisheries headquarters in Chilanga, Lusaka province. Other documentary sources such as satellite images and topographical maps on periodic variation in the size of the Kafue Flats were sourced from National Remote Sensing Centre (NRSC) in Lusaka.

3.10 Data Processing and Analysis

This study utilised both qualitative and quantitative methods in analysing data. In this case, the study employed descriptive and inferential statistics to analyse the research findings and draw conclusions. According to Cramer (1998), descriptive statistics more especially frequencies and central measure of tendencies allows for reduction of data to meaningful forms. Therefore, descriptive statistics were used in this study to obtain statistical characteristics such as the mean and standard deviation for climatic data. These statistics also enabled easier interpretation of the data enabling patterns to arise from the data. In addition to descriptive statistics, qualitative data was also analysed manually using common themes. For example, themes such as loss of life during strong winds and heavy were noted by most respondents.

According to Cramer (1998), inferential statistics allows developing explanations for observations made. Thus, inferential statistics were used in this study to analyse meteorological data such as rainfall and temperature. Using inferential statistics, the study merely tried to deduce from the sample what the population thought about the implications of climate variability on the fishing activities. This enabled judgements to be made by the researcher. The Inferential statistics obtained in this study include Covariance, Mann Kendall t-test values, linear trend values (at 95% confidence level) as well as decadal changes. Interestingly, inferential statistics permitted making of inferences from present data to more general conditions thus extending beyond the immediate data alone (Cramer 1998). Moreover, quantitative data was analysed using Statistical Package for Social Sciences (SPSS) to generate frequencies and percentages based on responses from the questionnaire.

Besides, An Clim (v5.025) software (Štěpánek 2008) and the Trend (V1.0.2) software (Chiew and Siriwardena 2005) centred on Mann Kendall (MK) and Sen's Slope Estimator (non- parametric tests) were used in analysing both rainfall and temperature data. The statistical significance of trend was determined using Mann Kendall (MK) test centered on the S (test statistic). Kizza *et al*. (2009) stated that Mann Kendall test method strongly withstands deviations and extreme effects arising from a linear relationship. The Mann Kendall method does not specify whether the trend in a times series is linear or non-linear (Jain *et al*. 2013) . Jain *et al*. (2013) points out that the null hypothesis (H_0) which indicates that there is no trend in the data is tested against the alternative hypothesis (H_1) of upward and downward trends. This study adapted the MK method to assess trends in the time series of rainfall and temperature. The n values in time series i.e. R1, R2, R3,…. Rn were substituted with their relative ranks i.e. X1, X2, X3,…….Xn (starting from the lowest i.e. 1 up until n). The Mann Kendall S (test statistic) is presented in Equation 1 below.

$$S = \sum_{k=1}^{n-1} [\sum_{j=k+1}^{n} sgn(R_j - R_k)] \tag{1}$$

Where

$$sgn(R_j - R_k) = +1 \; if (R_j - R_k) > 0$$

$$= 0 \; if \; (R_j - R_k) = 0$$

$$= -1 \; if \; (R_j - R_k) < 0$$

The S statistic approximates normal distribution with the mean when H_0 is true

$$\mu = 0$$

The variance of S is represented as:

$$\sigma = n(n-1)\,(2n+5)/18 \tag{2}$$

Therefore S and σ were used to compute the Z -statistic which represents significance levels

$$Z = |S|/\, \sigma^{0 \cdot 5} \tag{3}$$

Positive and negative values of S statistic indicate increasing (upward) and decreasing (downward) trends respectively. The null hypothesis was tested at 95 % confidence level in the present analysis of time series.

To determine magnitude of trend for observed variations in rainfall and temperature over the Kafue Flats of Zambia from 1982-2011, the rainfall and temperature data were subjected to statistical technique of Sen's Slope Estimator Test (Jain *et al*. 2013). Equation 4 and 5 below were used to compute Sen's Estimator (Sen 1968) while rainfall and temperature slopes (T_k) were derived from Equation (4) given as:

$$T_k = X_j - X_i/j - i \qquad (4)$$

For k = 1, 2………, N

Where $X_j - X_i$ are considered as data time series values at a time j and i (j > i), correspondingly. Sen's slope estimator is represented by the median of these N time series values of T_k derived as:

$$\beta = T^{N+1/2} \qquad \text{N is odd}$$

$$1/2\left(T + T^{N+2/2}\right) \qquad \text{N is even} \qquad (5)$$

Positive and negative values of β indicate increasing (upward) and decreasing (downward) trends in time series respectively. β values are expressed in magnitude of changes values.

Conversely, Microsoft excel spreadsheets were used to condense meteorological data and obtain statistical characteristics and specific graphs presented in the research findings. Additionally, the Microsoft excel spreadsheets were also used to fill in the gaps of rainfall and temperature data by calculating median values across the entire datasets for all the meteorological stations surrounding the Kafue Flats. In conclusion, although presented distinctively and appear separate, the whole analysis process involved combining qualitative and quantitative methods enabling triangulation of the results.

3.11 Ethical Considerations

The faculty of Natural and Agricultural Sciences at the University of Pretoria requires that all projects engaging human subjects be approved by the Ethics committee before conducting research. Thus, this study was only conducted after approval by Ethics Committee was granted.

During the survey, the researcher maintained confidentiality regarding personal information and identity of the respondents. The respondents were also allowed to withdraw from participating in the study at any given time they wanted. To meet all the ethical requirements, a consent form outlining the research title, purpose, procedures and benefits was given to each respondent for their signature before being interviewed. To this regard, a copy of the consent form is attached in Appendix V.

3.12 Chapter Summary

The above chapter basically acknowledged that the Kafue Flats lie in Kafue district within Southern Province of Zambia while Stratum I which is the study area extends from Kafue Gorge to Chanyanya Lagoon and includes a lot of fishing villages. The survey was however conducted only in the four fishing villages namely; Chanyanya, Nanga, Road Bridge and Chilumba fishing villages/camps. Outstandingly, the Kafue flats are among the most biologically diverse ecosystems in Zambia comprising of multifaceted patterns of lagoon, marshes and floodplain grasslands. Population densities are low in Kafue district thus the communities are generally small and are more concentrated along roads, lake edges and rivers. Fishing was identified to be the major economic activity among others. The research methodology employed both quantitative and qualitative methods of data collection and analysis. This enabled triangulation of the research findings and thus provided more consistent data on the implications of climate variability on the fishing and livelihood activities of the fisher-folk in the Kafue Flats.

The next chapter presents and discusses the research findings.

CHAPTER 4 : RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the research findings of the present investigation, it is divided into nine subsections where climatic data from Mumbwa, Kafue Polder, Mt Makulu, Magoye and Lusaka City meteorological stations are examined for the monthly, seasonal and annual variability with a central focus on the mean rainfall and temperature over the 1982-2011 period. Similarly, the research findings on the periodic size variation of the Kafue Flats catchment area using satellite imagery in change detection analysis are presented here. Besides, the chapter discusses the demographic and socio-economic characteristics of this study such as age, gender, level of education and sources of income. The research findings further confers the fisher-folk perceptions on key objectives; implications of climate variability, specifically changes in temperature, rainfall and wind on fisher-folk in the Kafue Flats, effects of seasonal variability on the fish catch, effect of climate variability on fishing duration, fishing techniques utilized by fisher-folk and the livelihood activities of the fisher-folk in the Kafue Flats. The results are presented in form of frequency tables, pie charts and line graphs. Finally, a summary of the chapter is also presented.

4.2 Preamble to Climatic Trends

Although the climate and the environment have been ominously changing at a faster rate since the twentieth century, humans have clearly ignored and not acknowledged the severity of such changes for a very long time. van Aardt *et al*. (2013) noted that the entire globe has seen this as a political rhetoric while environmental activists have been branded as zealots. Nevertheless, the reality is that the climate change science has very challenging and multifaceted impacts, risks and uncertainties hard enough to comprehend (van Aardt *et al.* 2013). Likewise, Ekpoh and Nsa (2011) observed that climate change subjects are ultimately the utmost contentious issues in the whole discipline of meteorology. Many scientists across the globe employed climate parameters such as temperature and rainfall in documenting temporal and spatial dimensions. For instance, Researchers such as López-Moreno *et al.* (2010); Jury (2013); Longobardi and Villani (2010) have recently highlighted the probable effects of Climate Variability and Change (CVC). Interestingly, Jain *et al*. (2013) noted that trend analysis of generic time series comprises of magnitude of change as well as significance of statistics. With increased attention on impacts of Climate change and Variability many researchers have widely employed non-parametric tests such as Mann-Kendall (MK) test and Sen's estimator in establishing climate change trends through time series analysis of temperature and rainfall data (Kendall (1975); Mann (1945); (Sen 1968). These non-parametric tests are particularly useful in analysing skewed data and data with missing values as was the case for this study (Arora *et al*. 2005). Hence, this study utilized both the non-parametric Mann-Kendall (MK) and Sen's Slope Estimator Tests. Rainfall and Temperature data for all the meteorological stations were uploaded into An Clim (v5.025) software (Štěpánek 2008) and Trend (V1.0.2) software (Chiew and Siriwardena 2005) for graphical representation and thorough analysis.

4.2.1 Climatic Trends in the Kafue Flats for the period 1982-2011

Secondary data that is rainfall and temperature readings were obtained from the Zambia Meteorological Department (ZMD) in Lusaka for the five meteorological stations surrounding the Kafue Flats in order to establish climatic trends over the Kafue Flats for the past three decades (1982-2011). Five stations namely, Lusaka city, Mumbwa, Mount Makulu, Kafue Polder and Magoye were selected, the reason being that all the named stations surround the Kafue Flats. This was crucial as an indicator to the phenomenon of climate variability. Specific locations of the five Meteorological stations are shown in Table 4.1 and Figure 4.1 below while climatic trends for rainfall and temperature are presented in the sections that follow.

Table 4.1 : Specific Locations of the Five Meteorological Stations Surrounding the Kafue Flats

Name of Meteorological Station	Latitude	Longitude
Mumbwa	15°04´S	27°11´E
Kafue Polder	15°46´S	27°55´E
Mt Makulu	15°32´S	28°14´E
Magoye	15°59´S	27°37´E
Lusaka City	15°25´S	28°19´E

Source: Zambia Meteorological Department (ZMD), 2014.

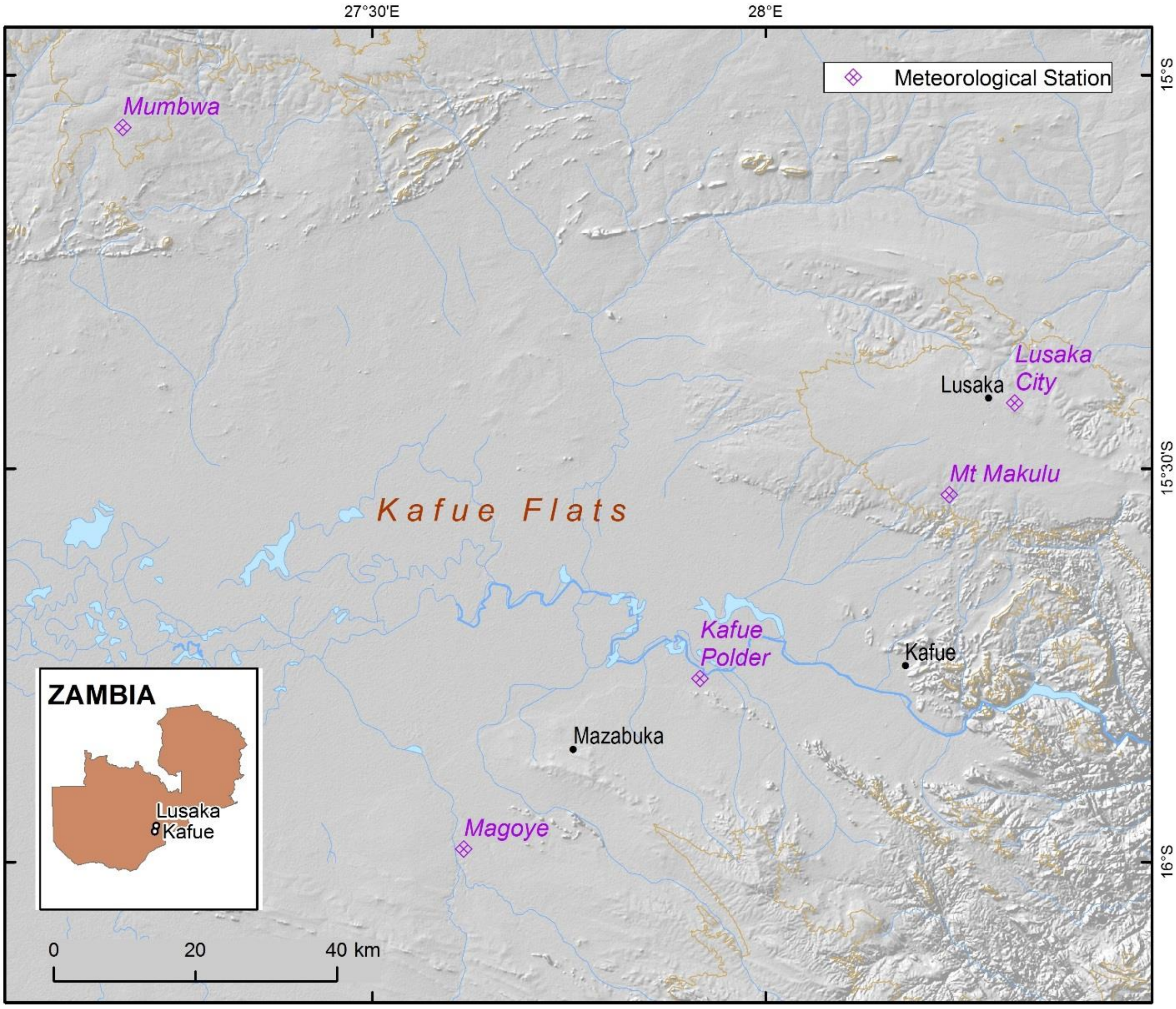

Figure 4.1: Location of the Five Meteorological Stations covered in the study

Source: Generated by Ingrid Boysen, 2014.

4.2.2 Data Analysis of Monthly, Seasonal and Annual Rainfall of the Kafue Flats for 1982-2011 climatic regime

4.2.2.1 Introduction

In order to study rainfall trends; analysing of monthly, seasonal and annual rainfall over 1982-2011 period was very cardinal. Understanding of climate variability impacts on fisheries also required temporal scale analysis of rainfall trends. In spite of the fact that people are fairly perceptive of climate variability, it is not as noticeable as weather variability because it happens over seasons and years. Thus, statistical analysis was achieved through monthly, seasonal and yearly averages of rainfall. By and large, analysis of rainfall trends using Anclim (v5.025) software (Štěpánek 2008) and Trend (V1.0.2) software (Chiew and Siriwardena 2005) provided pertinent and empirical climate variability results suitable for planning primarily at household, municipal and regional levels. Thus, statistical characteristics such as Arithmetic mean, the Highest and Lowest values in each particular year, the Standard Deviation, Covariance, Linear Trend (TL at 95%), Decadal changes (10 year period), Magnitude of change and the Mann Kendal rank statistic (t-value) were obtained for the five meteorological stations under study. The aforementioned statistical characteristics were obtained for Monthly Rainfall, Maximum and Minimum temperatures for five Meteorological stations (See Table 1-5 in Appendix VI). Moreover, different seasons for each year that is March, April, May (MAM), June, July, August (JJA), September, October, November (SON) and December, January, February (DJF) were also considered for data analysis in order to determine the seasonal variations for each of the climatic elements thus being able to ascertain how each climate element affects the fishing activities of the small scale fisher-folk in the Kafue Flats of Zambia. Henceforward, the seasonal averages were noted down while general conclusions were made on each statistical characteristic of the variables earlier mentioned.

4.2.2.2 Trend Analysis of Monthly Rainfall

Results of monthly rainfall trend analysis over the 1982-2011 period for the five Meteorological stations encompassing the Kafue Flats are presented below. The highest monthly rainfall of 578.5mm was observed from Kafue Polder Meteorological station in 1990 during the month of January, Mt Makulu recorded 559.3 mm as the highest monthly rainfall in the year 1989 during February, Mumbwa's highest monthly rainfall (457.1 mm) was observed in January 1989 while the highest monthly rainfall received for Lusaka City (419.9 mm) and Magoye (410.5 mm) meteorological stations were witnessed in 1990 and 1989 during the months of February and March respectively. The highest mean monthly rainfall for the 30 year period was observed in January for all Meteorological stations with Lusaka City recording the highest (229.48 mm). Conversely, the lowest mean monthly rainfall of 0.0 mm was recorded in different years during April up until October for all Meteorological stations (See the Tables 1-5 presented in Appendix VI). Notably, most of the meteorological stations experienced extreme monthly rainfall events in certain years i.e. 1982, 1986, 1987, 1988, 1989, 1991, 1993, 1994, 2000, 2004, 2007, 2008, 2009 and 2011. Moreover, Bwalya (2010) reported that dry parts of Southern and Western Provinces of Zambia have predominantly experienced increased rainfall variability (NB: a greater portion of the Kafue Flood Plain Fishery lies in Southern Province). Mukheibir and Sparks (2006) stated that a dry year often has significant consequences on livelihoods of people. Thus, water stressed areas are more prone to climate change impacts especially when coping and adaptive capacities of people living in such areas is particularly low (Schulze and Maharaj 2004; Mukheibir and Sparks 2006). Certain parts of Zambia such as the Kafue Flats already experience stress in water resources and as such, current information on rainfall variability is primarily essential for appropriate planning in all sectors of the economy (Bwalya 2010). The average monthly rainfall trends over a 30 year period (1982 -2011) for the five Meteorological stations encompassing the Kafue Flats indicate fluctuating scenarios where monthly rainfall amounts increase and decrease with outliers in certain cases.

Furthermore, the climatic regime (1982-2011) indicates that rainfall for the month of November for four of the Meteorological stations surrounding the Kafue Flats have significant Mann Kendall t-values at 95% confidence level i.e. 0.297 for Magoye, 0.292 for Lusaka City, 0.200 for Mt Makulu and 0.154 for Mumbwa (See the Tables 1-5 presented in Appendix VI). However, all months for Kafue Polder Meteorological station have no significant Mann Kendall t-values (See Table 3 presented in Appendix VI). Moreover, the 1982-2011 climatic regime gives evidence of fluctuating trends in monthly rainfall amounts. For example, the month of March and November for Lusaka City showed statistically significant increasing trend at a < 0.05 with z-statistic values of 1.98 and 2.284 respectively (See Table 6 in Appendix VII). The month of October for Lusaka City, however, indicated statistically significant decreasing trend at a < 0.05 with z-statistic of -1.998. Similarly, both March and November months for Kafue Polder and Magoye exhibited statistically significant increasing trends at a < 0.05 with z-statistics of 2.07 and 2.319 respectively (See Table 6 in Appendix VI). Besides, February and October months for Mumbwa showed statistically significant decreasing trends at a < 0.05 with z-statistics of -2.105 and -2.212 respectively. Notably, the month of April for Mumbwa depicted a statistically significant decreasing trend at a < 0.1 with a z-statistic of -1.748. However, all months for Mt Makulu were not statistically significant at a = 0.10 (See Table 6 in Appendix VI).

A closer analysis disclosed that the 1982-2011 climatic regime received more rainfall throughout the 30 year period during the month of November up until March for all the meteorological stations surrounding the Kafue Flats (See the Tables 1-5 presented in Appendix VI). Interestingly, January out of the whole twelve months recorded the highest mean monthly rainfall for all meteorological stations during 1982-2011 period. Bailey (1998) noted that the ability to understand spatial distribution of various ecological units is critically dependent on proper consideration of annual rainfall amounts and its seasonal distribution. Henceforward, the findings from this study are highly significant in resolving water resources challenges (Nel and Sumner 2006) and could perhaps help identify climate change impacts on fisheries (Nsubuga *et al*. 2013). Accordingly, MK test results for most meteorological stations as shown in Tables 1-5 in Appendix VI ranged between -1.000 mm and 0.807 mm. This certainly suggests that the observed monthly rainfall time series over the 30 year period experienced both increasing (upward) and decreasing (downward) trends. Above and beyond, numerous factors could be associated with the rainfall variability observed over the Kafue Flats. For instance, increased fluctuations in global surface temperatures (Washington and Preston 2006) may perhaps generate abnormal rainy conditions over Southern Africa and Zambia in particular. Similarly, Nel (2009) and Jury (2013), observed that severe occurrences of El Niño/La Niña, cyclones and ENSO have often influenced rainfall patterns in Southern Africa. Consequently, the observed rainfall variability over the Kafue Flats could be attributed to fluctuations in global sea surface temperatures as well as increased variations in rainfall patterns. Over-all, the observed monthly rainfall from 1982-2011 depicted increasing and decreasing trends at different rates. For instance, certain months exhibited statistically significant trends while other months did not.

4.2.2.3 Trend Analysis of Annual Rainfall

The highest amount of annual rainfall received over the 1982-2011 period for the five Meteorological stations include 1385.6 mm in 1989 (Mt Makulu), 1300.7 mm in 1989 (Mumbwa), 1222.7 mm in 1989 (Lusaka city), 1012.3 mm in 2000 (Kafue Polder) and 1074.1 mm in 2007 (Magoye). Meanwhile, the lowest annual rainfall amounts for all the stations are; 314.8 mm in 1995 (Lusaka city), 459.5 mm in 1987 (Kafue Polder), 398.6 mm in 1995 (Mumbwa), 456.3 mm in 2002 (Magoye) and 498.9 mm in 2002 for Mt Makulu (See excel sheet in Appendix VII). Table 4.2 below indicates the highest and lowest annual rainfall amounts for the five Meteorological stations during the 1982-2011 climatic regime. Notably, Mt Makulu recorded the highest annual rainfall amounts among the five stations. The three stations (Mt Makulu, Mumbwa and Lusaka City) recorded the highest annual rainfall amounts in the same year that is 1989 while Magoye and Kafue Polder Meteorological stations recorded the highest annual rainfall amounts in 2000 and 2007 respectively. Conversely, there is a variation in the lowest annual rainfall amounts received; Mt Makulu and Magoye stations received the lowest annual rainfall amounts in the same year (2002) while the other three stations (Mumbwa, Lusaka City and Kafue Polder) received the lowest annual rainfall amounts in 2005, 1995 and 1987 respectively. Hitherto, the annual rainfall received across the Kafue

Flats based on rainfall trend analysis of the five Meteorological stations depicted an upward and downward trend as shown in figure 4.2 below. Nonetheless, no rainfall was recorded for all meteorological stations during the months of June up until September because rainfall is not normally received in these months unless an anomaly occurs, yet it is rare for such to occur. Besides, if an anomaly event occurs, it may perhaps be associated with oscillation events and seasonal variations.

Table 4.2 : Highest and Lowest Annual Rainfall Amounts from 1982 - 2011

Name of Meteorological Station	Highest Annual Rainfall		Lowest Annual Rainfall	
	Amount (mm)	year	Amount (mm)	Year
Mt Makulu	1385. 6	1989	498.9	2002
Mumbwa	1300.7	1989	399.8	2005
Lusaka City	1222.7	1989	314.8	1995
Magoye	1074.1	2007	456.3	2002
Kafue Polder	1012.3	2000	459.5	1987

Source: ZMD, 2014.

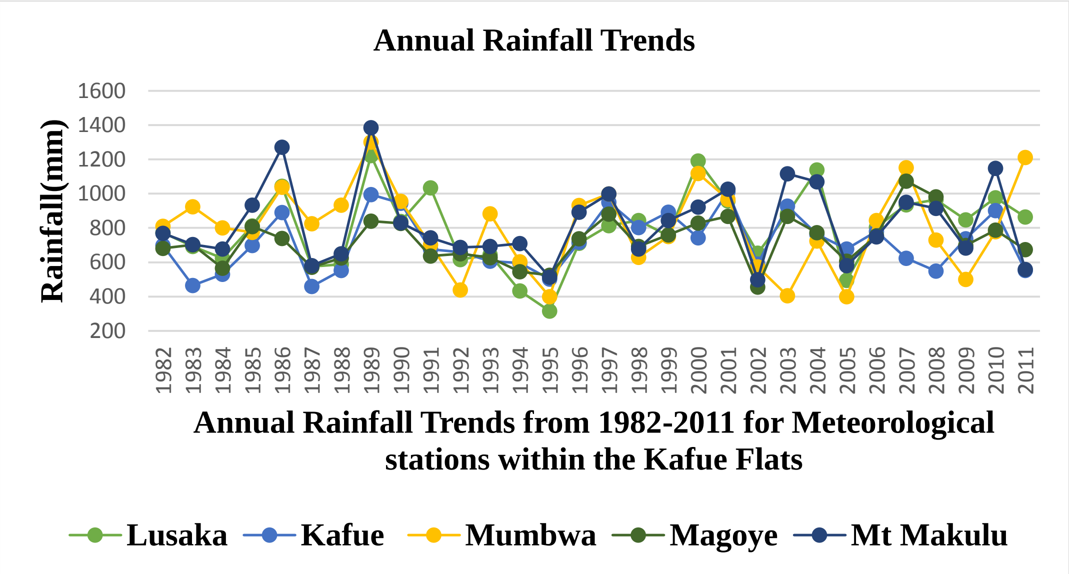

Figure 4.2 : Annual Total Rainfall trends for the five Meteorological stations surrounding the Kafue Flats of Zambia

Source: Field work data, 2014.

Overall, trend analysis of annual rainfall amounts depicted both increasing and decreasing trends. Thus, the mean annual rainfall in the Kafue eco-region had been changing at a rate of

3.0545 mm per annum during the 30 year period (See figure 4.3 below). However, the observed trends in annual rainfall are not statistically significant at a = 0.10 and z-statistic of 0.928.

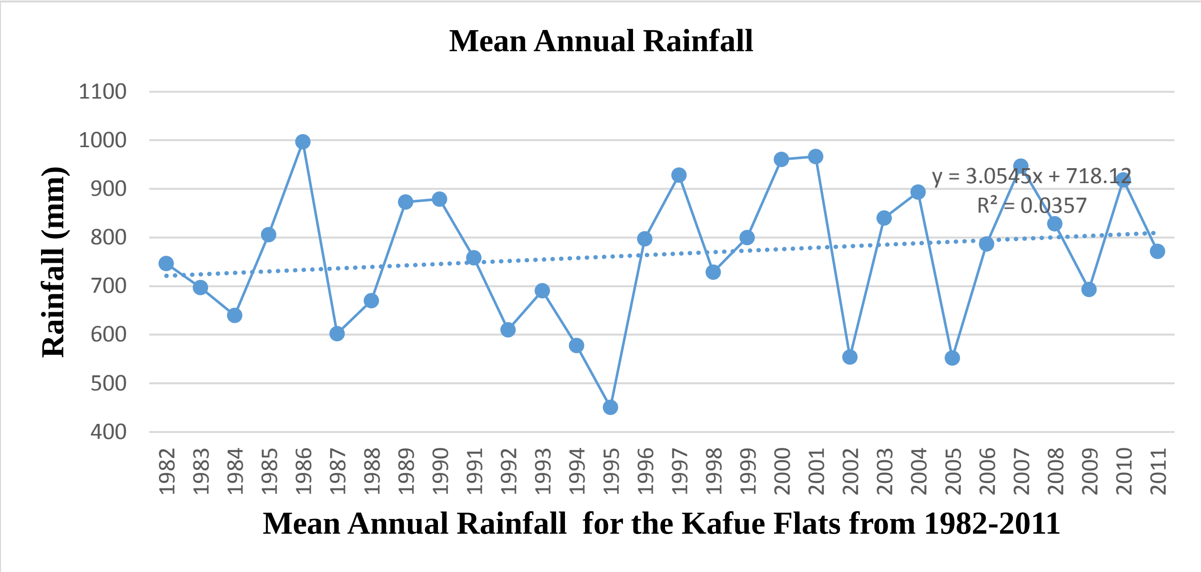

Figure 4.3 : Average Annual Rainfall Trends for the Kafue Flats from 1982-2011

Source: Field work data, 2014.

4.2.2.4 Trend Analysis of Seasonal Rainfall

According to Nel (2009); Nel and Sumner (2006), monthly rainfall totals presented as percentages of the total annual rainfall often denote seasonality. Thus, seasonality analysis for 30 years in this study was centred on monthly rainfall averages recorded during 1982 to 2011. Understanding of seasonal rainfall trends required dividing each year into four different climatic seasons in spite of the fact that there are only three seasons in Zambia. The four subdivided climatic seasons consist of September to November (SON) representing spring, December to February (DJF) representing summer, March to May (MAM) representative of autumn and June to August (JJA) representing winter. This type of monthly aggregation has been extensively used in seasonality analysis of both temperature and rainfall patterns by several scholars throughout the world (Kruger and Shongwe 2004; Tshiala *et al*. 2011; Nsubuga *et al*. 2013; López-Moreno *et al*. 2010; Collins 2011).

Rainfall in the Kafue eco-region is highly seasonal with an annual average of 600-900 mm. The summer months of November through February often receive increased rainfall amounts than the rest of the months. As can be seen from figure 4.4 to 4.23 representing seasonal rainfall variations for the five Meteorological stations: MAM season for Kafue Polder, SON seasons for Lusaka, Magoye, Mt Makulu and Mumbwa Meteorological stations depicted positive trends in rainfall amounts received (as seen from the blue trend lines in figure 4.8, 4.14, 4.15, 4.16 and 4.17 below). Meanwhile, JJA, SON and DJF seasons for all meteorological stations depicted upward and downward trends which were not statistically significant at a = 0.10 (See figure 4.4 to 4.23 below and Table 4.3 below). Notably, the graphs for JJA rainfall seasons for all the meteorological stations depict almost constant trend lines and this is so because no rainfall is received in the months of June, July and August in the whole country unless an anomaly occurs. For instance, the JJA graph for Mumbwa Meteorological station has the trend line equation equal to zero (y=0 and R^2=0) meaning that there was no rainfall received in the JJA season. Overall, nearly all seasons for most meteorological stations depict increasing and decreasing seasonal rainfall trends which are not statistically significant at a = 0.10 (See Table 4.3 below). Interestingly, only MAM season for Mumbwa depicted statistically significant decreasing trend at a < 0.10 with a z-statistic of -1.659 (See Table 4.3 below).

Table 4.3 : Trend values (z-statistic) for Seasonal Rainfall

Station	z-statistic for each season			
	MAM	JJA	SON	DJF
Lusaka city	0.99	-0.375	1.499	0.785
Kafue Polder	1.481	0.071	-0.357	0.339
Mumbwa	**-1.659**	0	0.821	-0.178
Magoye	0.535	-0.036	1.338	1.035
Mt Makulu	-0.357	-0.464	0.803	0.553

NB: Bold value shows statistically significant trend (at a < 0.10) with decreasing trend.

With regards to seasonal rainfall totals as shown in the Excel Spreadsheet in Appendix VII, the five Meteorological stations recorded the highest seasonal rainfall amounts during December, January and February (DJF season) throughout the 1982-2011 climate regime. The highest seasonal rainfall amounts recorded are 382.4000 mm (Mt Makulu), 329.0667 mm (Lusaka City), 316.0667 mm (Mumbwa), 272.4667 mm (Magoye), and 299.4333 mm (Kafue Polder). Outstandingly, Mt Makulu Meteorological station recorded the highest mean seasonal rainfall among the five stations for 30 year period. However, the lowest seasonal rainfall amount recorded by all Meteorological stations was 0.0 mm more importantly during June, July and August (JJA season). Often times, throughout all the three ecological zones (regions) of Zambia, the highest amounts of rainfall are basically recorded in DJF season with the lowest rainfall amounts in JJA season as shown in the Excel Spreadsheet in Appendix VII. In view of the whole DJF dataset, Mt Makulu Meteorological station received the highest seasonal rainfall amount of 382.4 mm in the year 1989. Nonetheless, Mumbwa Meteorological station recorded the lowest seasonal rainfall amount of 68.4 mm in the year 2005. By and large, multi-decadal analysis of seasonal rainfall trends showed that DJF season depicted positive trends in seasonal rainfall amounts received for the four meteorological stations except for Mumbwa. Conversely, the MAM and SON seasons recorded moderate seasonal rainfall amounts for all Meteorological stations during the 1982-2011 climate regime. Meanwhile, the lowest seasonal rainfall amounts were observed in JJA for the entire study period for all the meteorological stations. Consequently, analysis of seasonal rainfall depicted increasing trends for MAM and DJF for most of the meteorological stations while JJA seasons for most of the meteorological stations showed decreasing trends. Figure 4.4 to 4.23 below show the seasonal rainfall trends for all Meteorological stations surrounding the Kafue Flats.

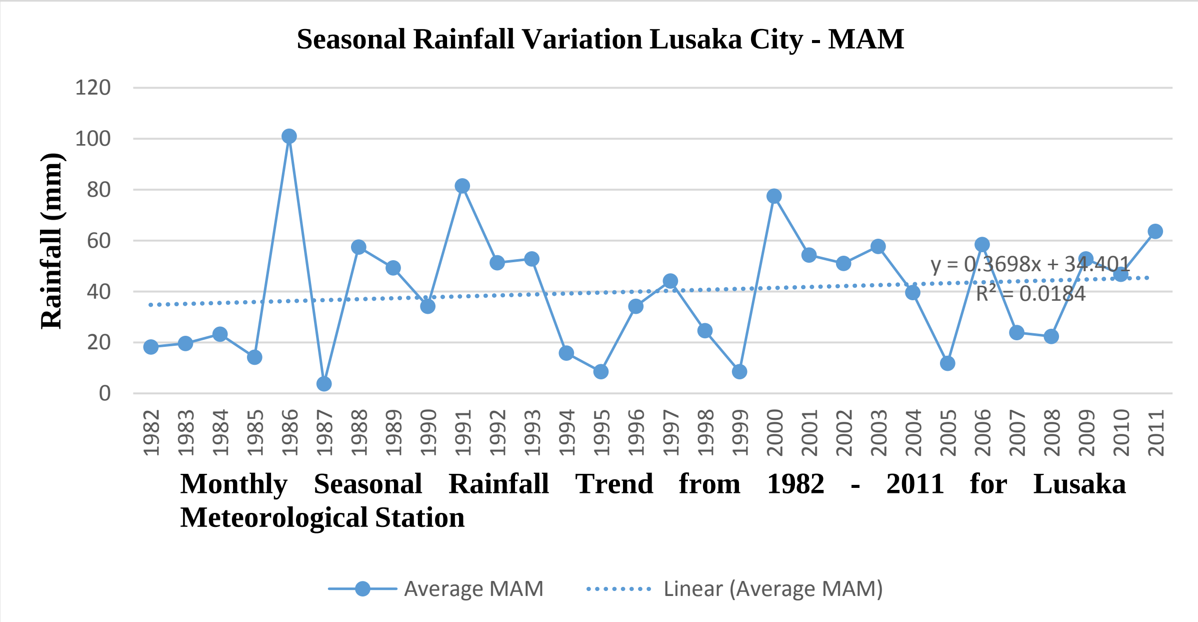

Figure 4.4 : Seasonal Rainfall Average Trend (MAM) from 1982-2011 for Lusaka City

Source: Field work data, 2014.

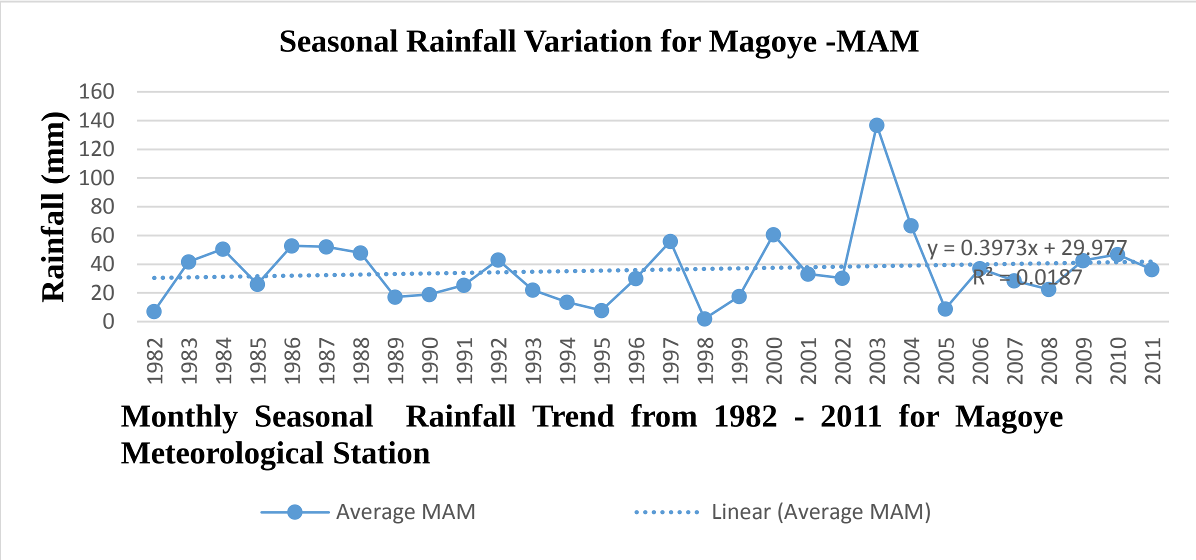

Figure 4.5 : Seasonal Rainfall Average Trend (MAM) from 1982-2011 for Magoye

Source: Field work data, 2014.

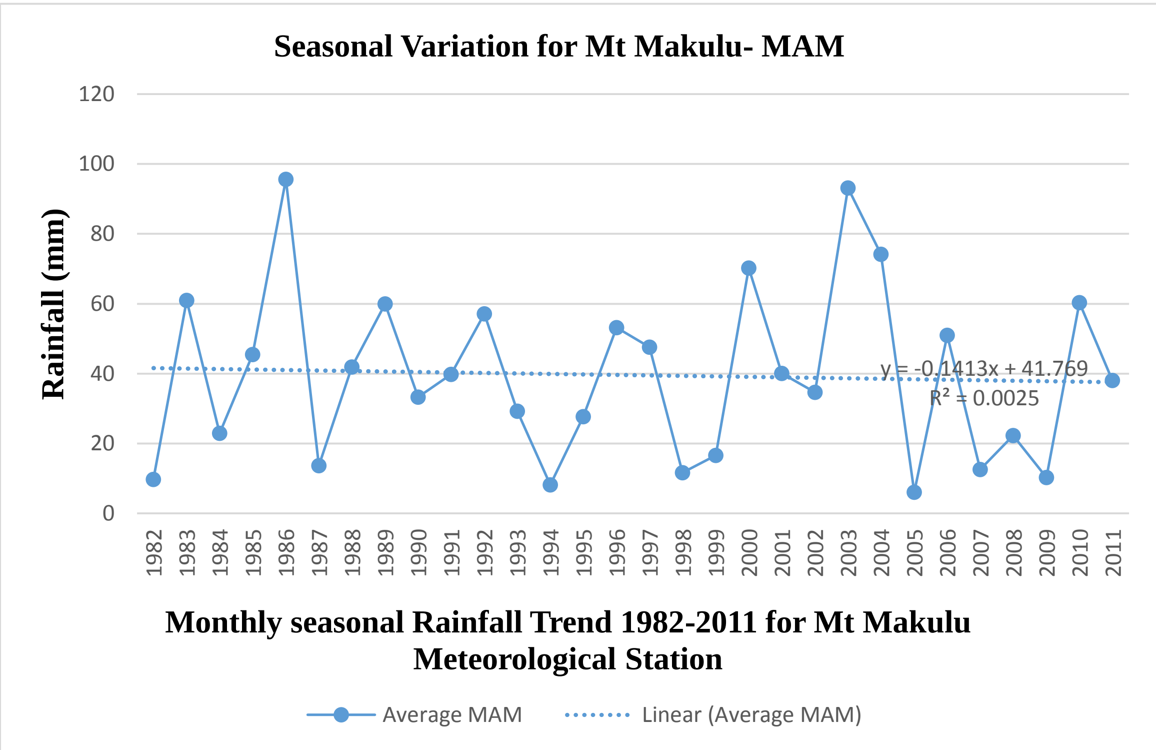

Figure 4.6 : Seasonal Rainfall Average Trend (MAM) from 1982-2011 for Mt Makulu

Source: Field work data, 2014.

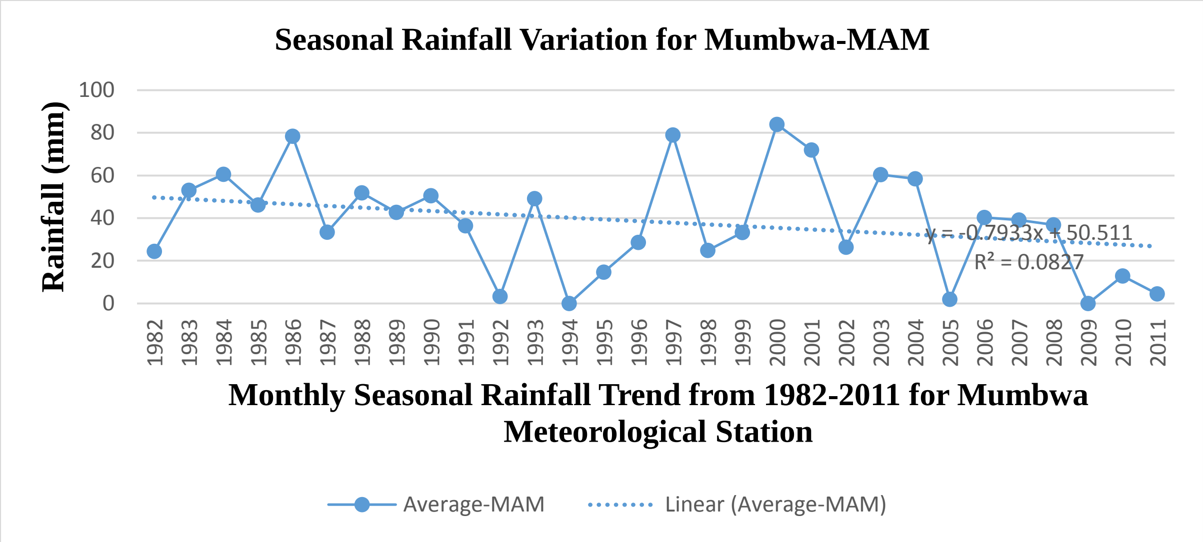

Figure 4.7 : Seasonal Rainfall Average Trend (MAM) from 1982-2011 for Mumbwa

Source: Field work data, 2014.

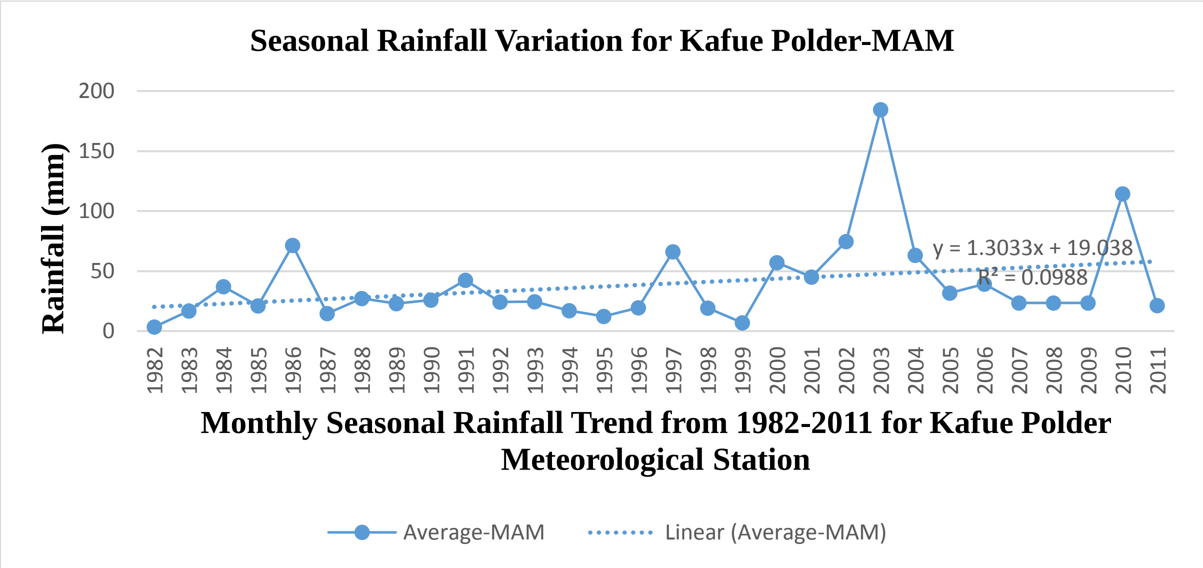

Figure 4.8 : Seasonal Rainfall Average Trend (MAM) from 1982-2011 for Kafue Polder

Source: Field work data, 2014.

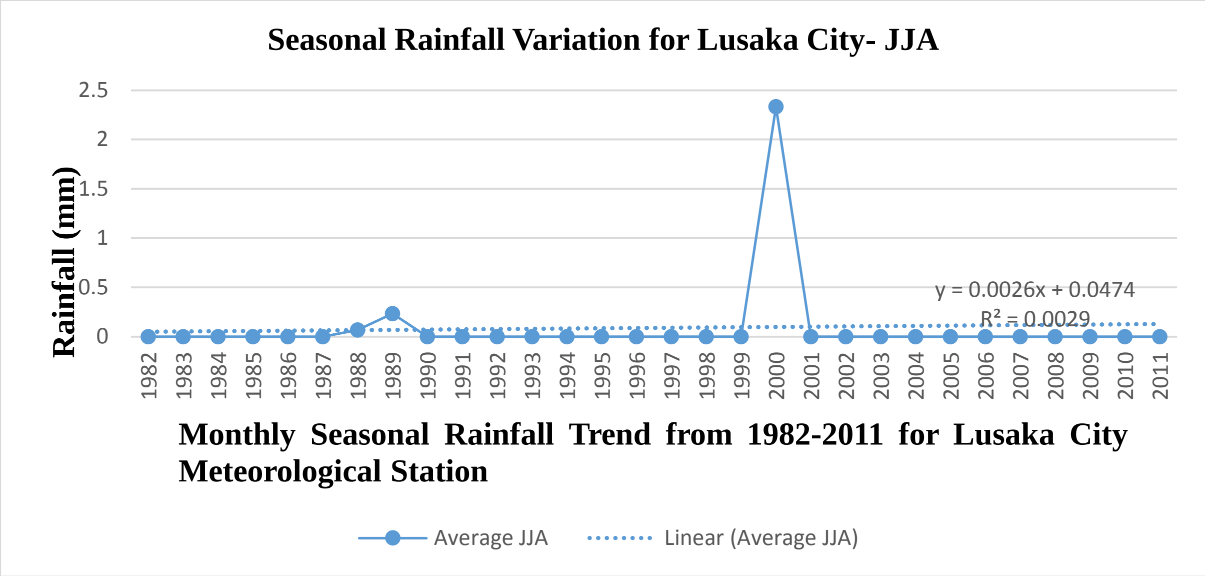

Figure 4.9 : Seasonal Rainfall Average Trend (JJA) from 1982-2011 for Lusaka City

Source: Field work data, 2014.

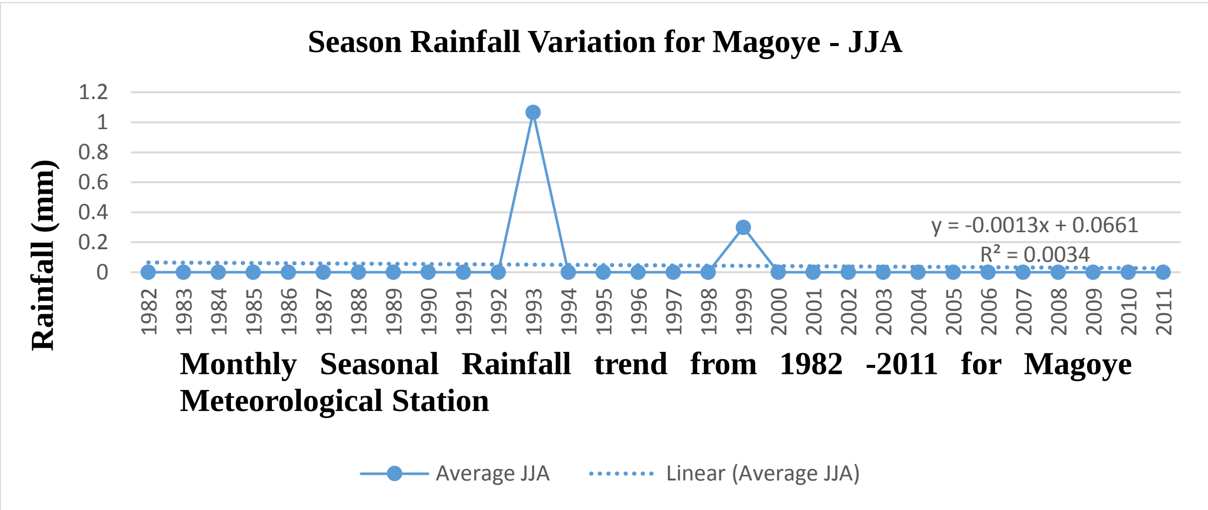

Figure 4.10 : Seasonal Rainfall Average Trend (JJA) from 1982-2011 for Magoye

Source: Field work data, 2014.

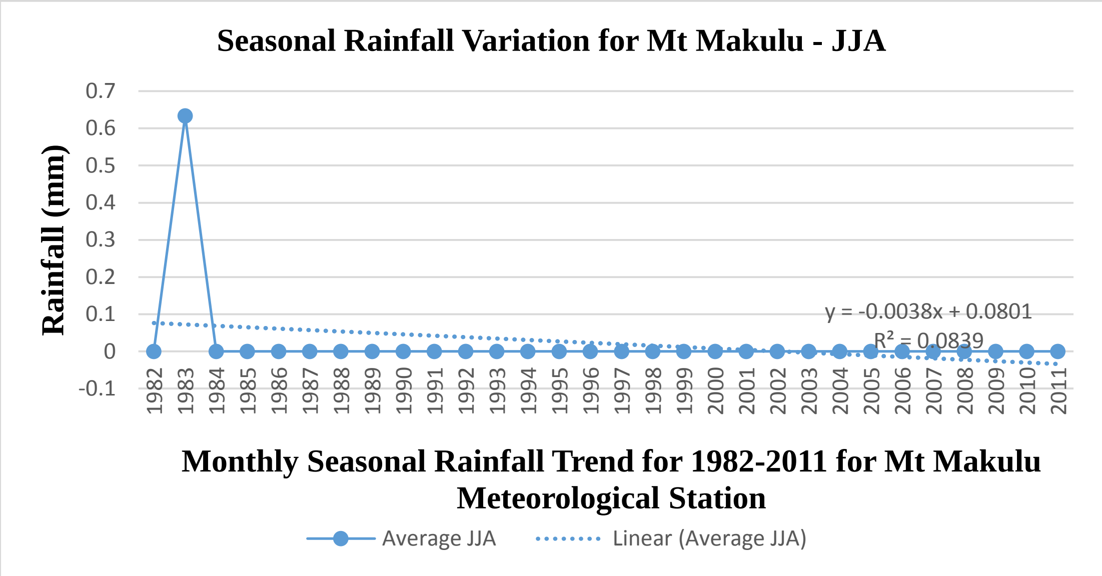

Figure 4.11 : Seasonal Rainfall Average Trend (JJA) from 1982-2011 for Mt Makulu

Source: Field work data, 2014.

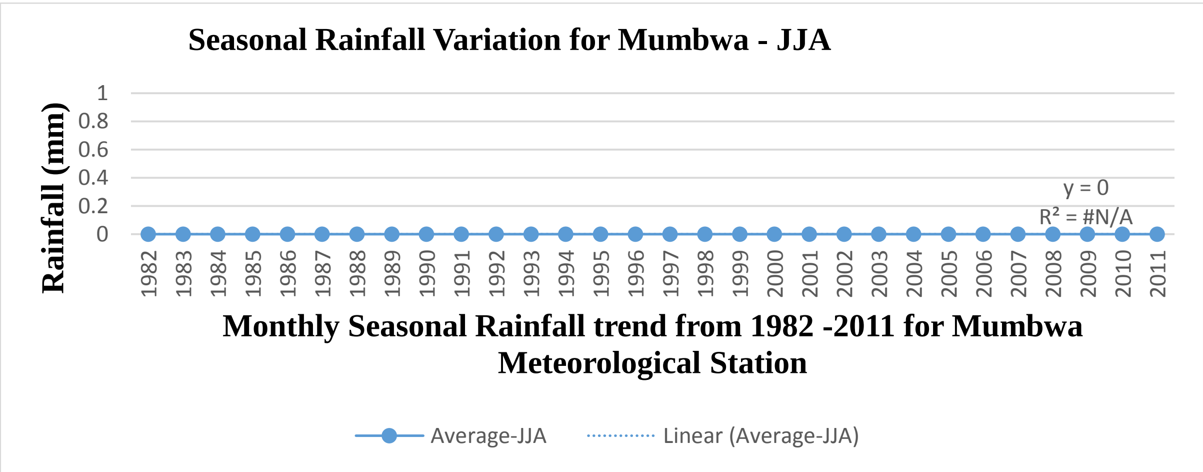

Figure 4.12 : Seasonal Rainfall Average Trend (JJA) from 1982-2011 for Mumbwa

Source: Field work data, 2014.

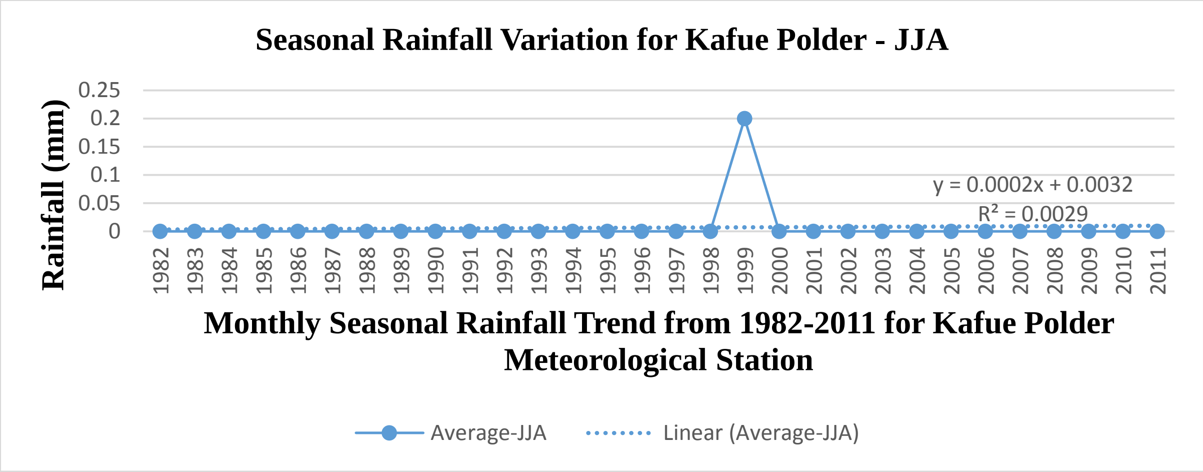

Figure 4.13 : Seasonal Rainfall Average Trend (JJA) from 1982-2011 for Kafue Polder

Source: Field work data, 2014.

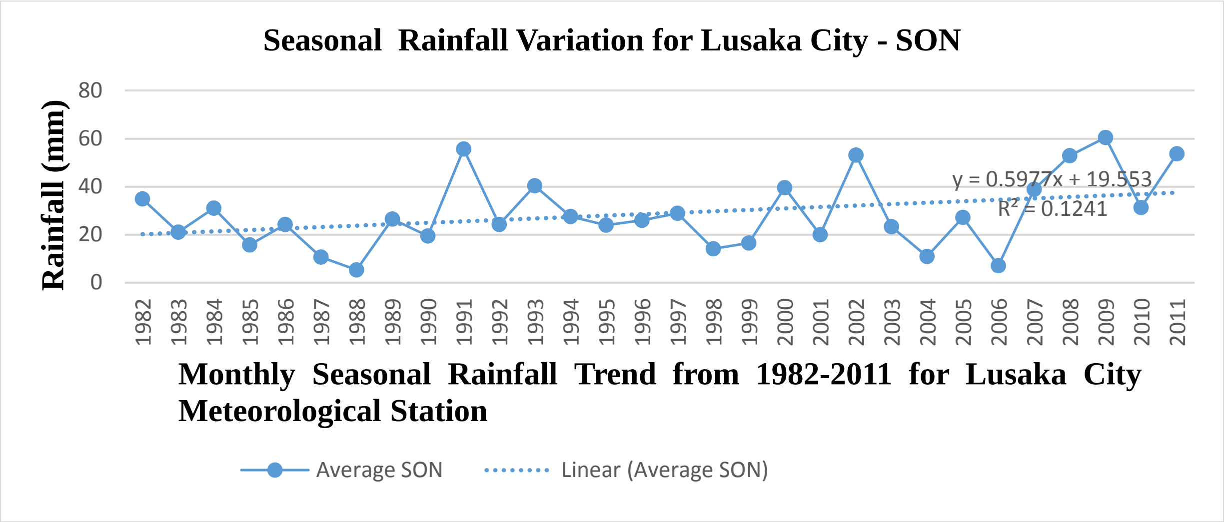

Figure 4.14 : Seasonal Rainfall Average Trend (SON) from 1982-2011 for Lusaka City

Source: Field work data, 2014.

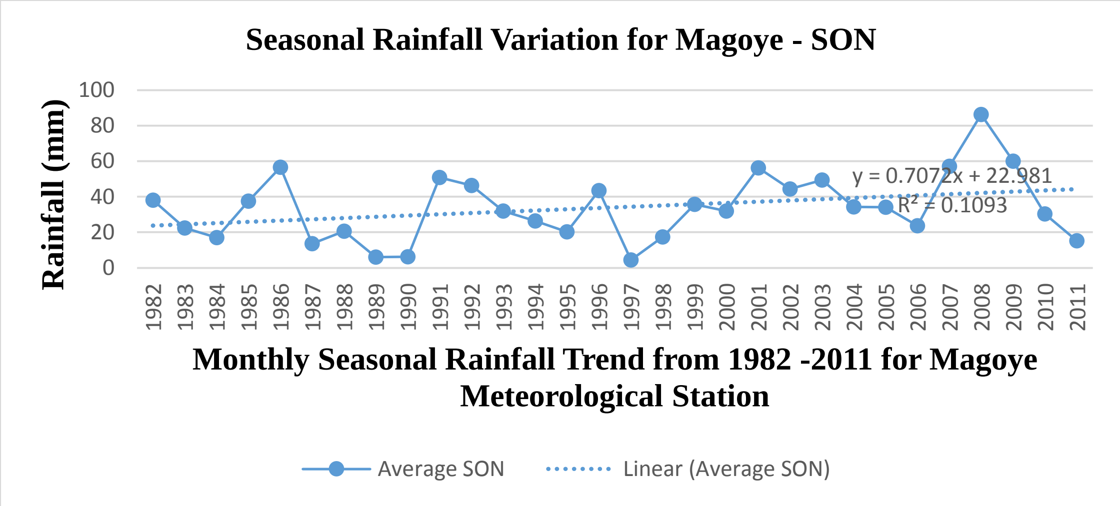

Figure 4.15 : Seasonal Rainfall Average Trend (SON) from 1982-2011 for Magoye

Source: Field work data, 2014.

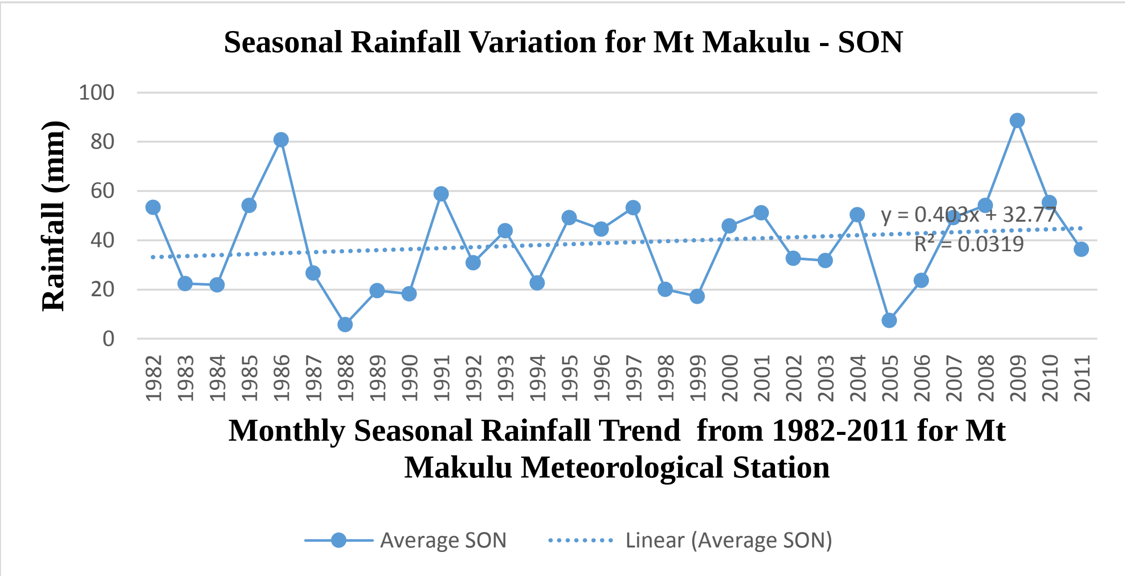

Figure 4.16 : Seasonal Rainfall Average Trend (SON) from 1982-2011 for Mt Makulu

Source: Field work data, 2014.

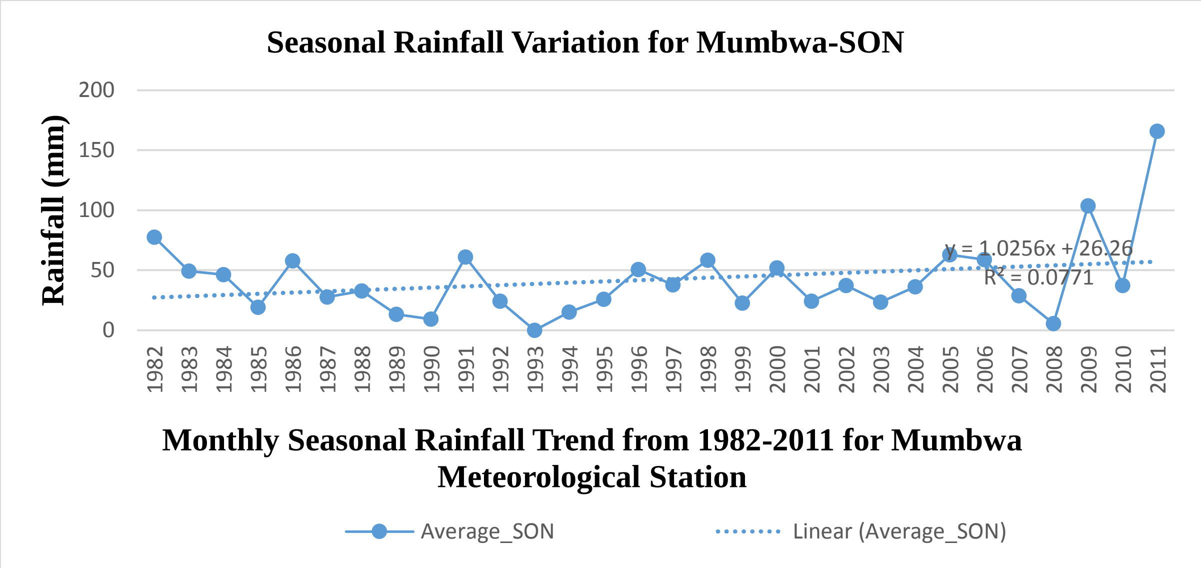

Figure 4.17 : Seasonal Rainfall Average Trend (SON) from 1982-2011 for Mumbwa

Source: Field work data, 2014.

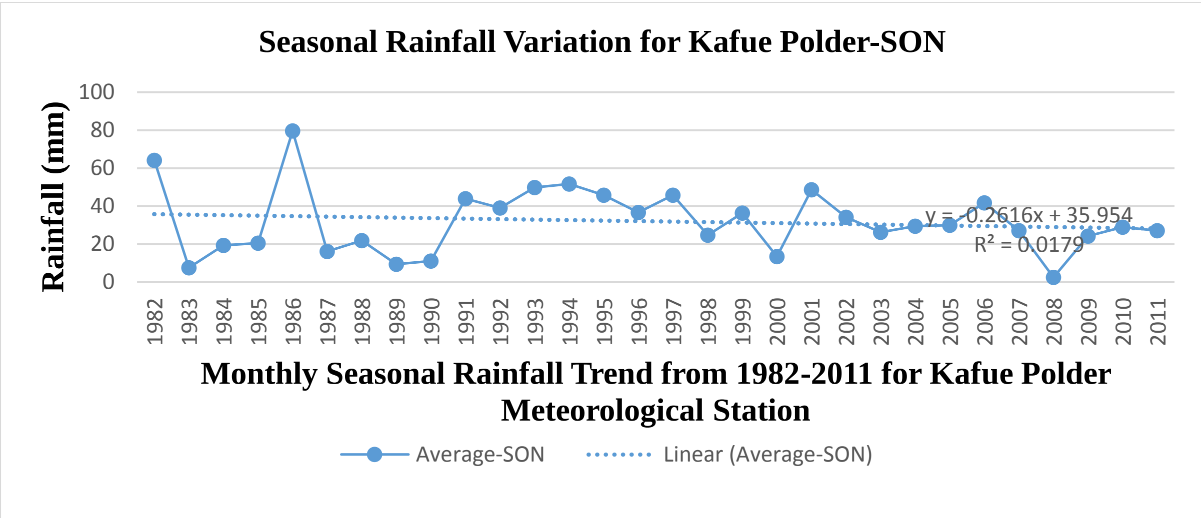

Figure 4.18 : Seasonal Rainfall Average Trend (SON) from 1982-2011 for Kafue Polder

Source: Field work data, 2014.

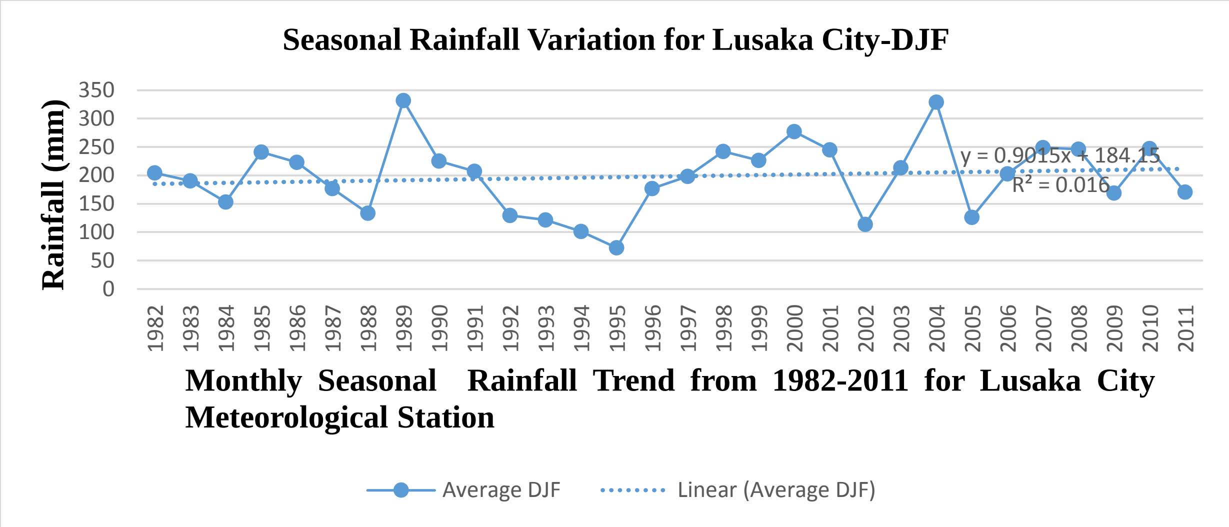

Figure 4.19 : Seasonal Rainfall Average Trend (DJF) from 1982-2011 for Lusaka City

Source: Field work data, 2014.

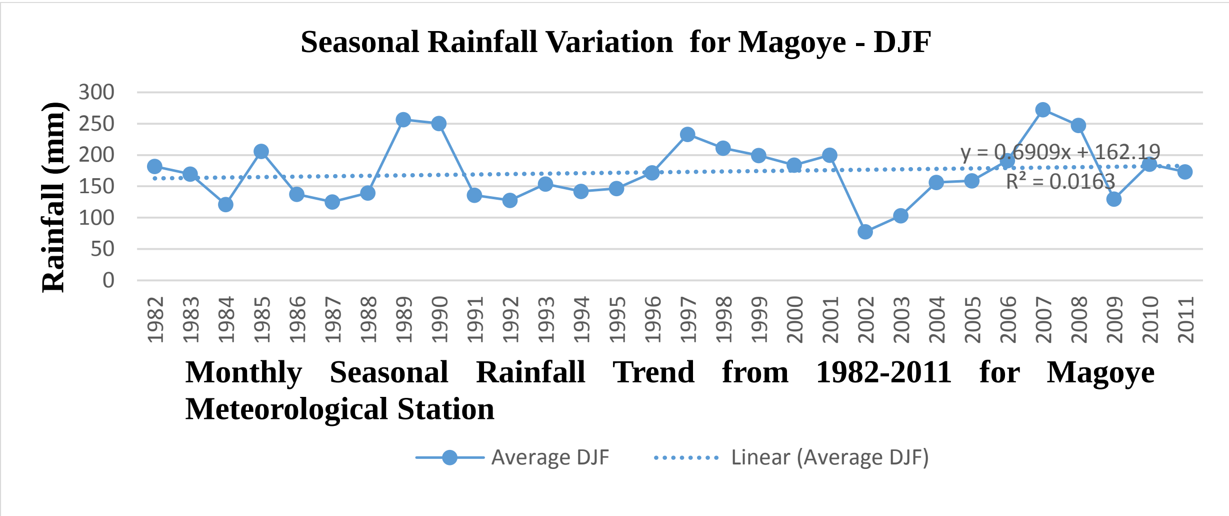

Figure 4.20 : Seasonal Rainfall Average Trend (DJF) from 1982-2011 for Magoye

Source: Field work data, 2014.

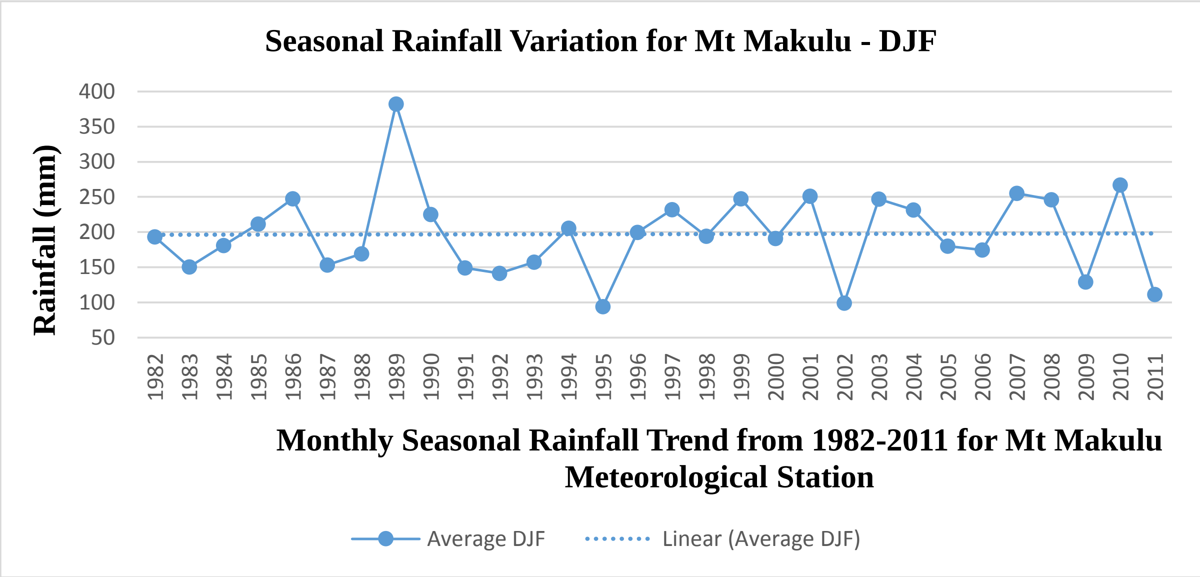

Figure 4.21 : Seasonal Rainfall Average Trend (DJF) from 1982-2011 for Mt Makulu

Source: Field work data, 2014.

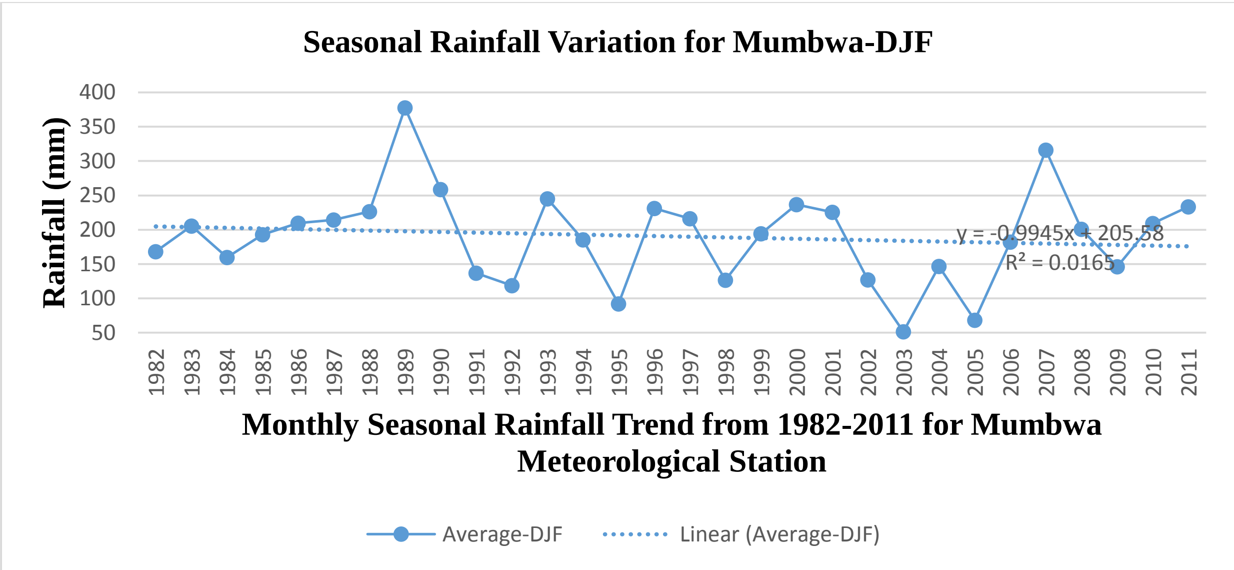

Figure 4.22 : Seasonal Rainfall Average Trend (DJF) from 1982-2011 for Mumbwa

Source: Field work data, 2014.

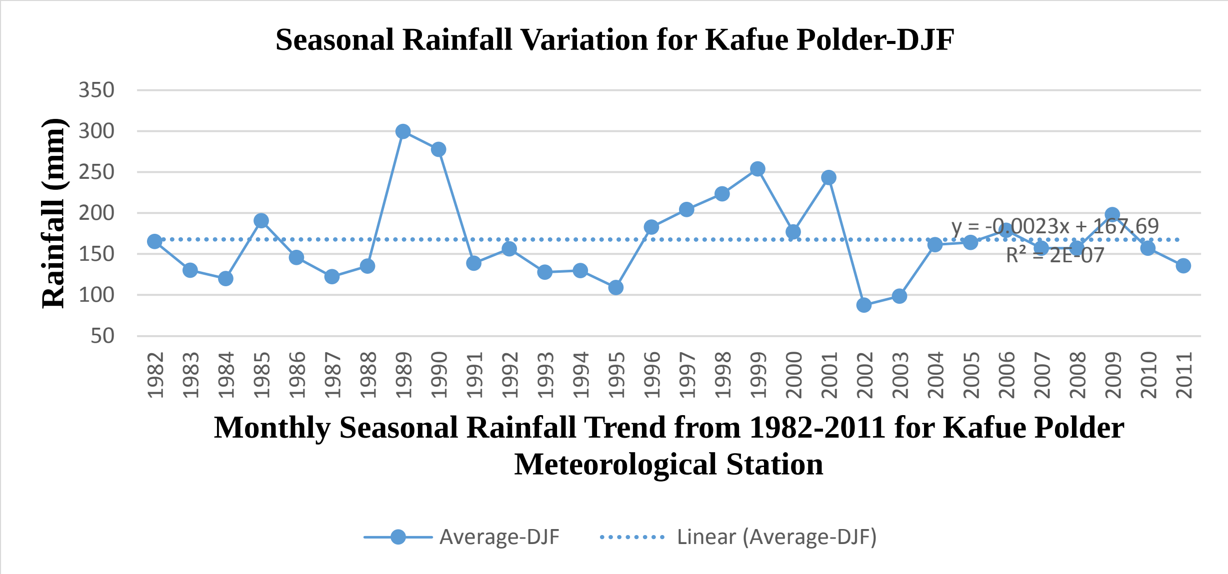

Figure 4.23 : Seasonal Rainfall Average Trend (DJF) from 1982-2011 for Kafue Polder

Source: Field work data, 2014.

4.2.3 Temperature Changes and Trends

Time series of monthly, seasonal and annual temperature trends of the Kafue Flats were examined in order to provide a micro scenario of temperature variations over the 1982-2011 period. Knowledge of micro temperature trends was very important in accomplishing the study aim. Climatic datasets consisting of observed monthly temperature approximations for the 1982-2011 period were utilised in this study. These datasets were obtained from the Zambia Meteorological Department in Lusaka. To ensure accuracy of trend results and completeness of data, quality checks were executed on whole climate datasets. Precisely, temperature datasets were visually inspected (Nsubuga *et al.* 2013) and where possible, record and infilling techniques were used to replace missing gaps in the datasets (Schulze and Maharaj 2004). Hitherto, long term median values were calculated across the entire temperature dataset in order to fill in the missing gaps. In general, the climate datasets were comprehensive enough to estimate related temperature variables. Subsequently, monthly temperature means for a period of 30 years were obtained after the observed monthly temperature estimates were averaged. Accordingly, the computed monthly and seasonal temperature means were then uploaded into An Clim (v5.025) software (Štěpánek 2008) and Trend (V1.0.2) software (Chiew and Siriwardena 2005) for graphical representation and thorough analysis. Notably, the datasets helped to derive several time series such as monthly, seasonal and annual variability of both minimum and maximum temperatures.

4.2.3.1 Analysis of Monthly, Seasonal and Annual Temperatures for the Five Meteorological Stations

4.2.3.1.1 Analysis of Monthly Maximum Temperatures

A detailed analysis exhibited that throughout the 30 year climate regime, the month of October recorded the highest Arithmetic mean monthly maximum temperature for all the meteorological stations that is 33.5733 °C for Magoye, 33.3367 °C for Kafue Polder, 32.8100 °C for Mumbwa, 32.1067 °C for Mt Makulu and 30.9200 for Lusaka City (See Tables 1-5 in Appendix VI). Moreover, the lowest Arithmetic mean monthly maximum temperature (25.503°C for Magoye, 24.9067 °C for Mumbwa, 24.2833 °C for Mt Makulu, and 23.0400 °C for Lusaka) was observed in July for the four meteorological stations except Kafue Polder (26.0100°C) that recorded its lowest mean monthly maximum temperature in the month of June. Notably, Magoye (33.5733°C) and Lusaka City (23.0400°C) recorded the highest and lowest mean monthly maximum temperature for the entire 1982-2011 climate regime respectively. Additionally, the highest monthly maximum temperature recorded for the entire 30 year period was 43.2 °C during the month of October in the year 2005. Meanwhile, the lowest monthly maximum temperature of 21.6°C was recorded in July both in 1993 and 2010 for the 1982-2011 climate regime. Lusaka City and Magoye Meteorological stations recorded the highest (6.28) and lowest (2.56) covariance in the months of March and September for monthly maximum temperatures respectively, as shown in Table 4.4 below.

Table 4.4 : Covariance Values for Monthly Maximum Temperatures from 1982-2011

Name of Station	Highest Covariance	Lowest Covariance
Mumbwa	3.35	3.02
Lusaka	6.28	2.72
Kafue Polder	4.07	2.90
Magoye	4.42	2.56
Mt Makulu	4.38	2.92

Source: Field work data, 2014.

Subsequently, the calculated Mann Kendal (MK) values for maximum temperatures for the entire 30 year climate regime indicated that certain months from all meteorological stations were either significant or non-significant. All the other months not presented in Table 4.5 below exhibited non-significant MK values for the entire 30 year climate regime. Some of the Mann Kendall values that were noted to be significant and non-significant for monthly maximum temperatures through the 1982-2011 climatic regime are shown in Table 4.5 below (also see Tables 1-5 in Appendix VI).

Table 4.5 : Mann Kendall Values for Monthly Maximum Temperatures from 1982-2011

Name of the Station	Mann Kendall value	Level of Significance	Month
Mumbwa	0.338	Significant	October
Lusaka	0.246 and 0.237	Significant	August and October
Kafue Polder	0.195	Non-significant	October
Magoye	0.260	Non-significant	November
Mt Makulu	0.287	Significant	October

Source: Field work data, 2014.

Further, the highest and lowest magnitude of change for monthly maximum temperatures were 0.1171(Mumbwa) and -0.0229 (Kafue Polder) for October and September months respectively (See Table 4.6).

Table 4.6 : Magnitude of Change for Monthly Maximum Temperatures from 1982-2011

Name of Station	Highest Magnitude of Change	Lowest Magnitude of Change
Mumbwa	0.1171	-0.0141
Lusaka	0.0489	-0.0060
Kafue Polder	0.0373	-0.0229
Magoye	0.0622	-0.0119
Mt Makulu	0.0615	-0.0172

Source: Field work data, 2014.

Regarding linear trend values for monthly maximum temperatures, the steepest trend (2.615) was recorded by Magoye Meteorological station while Kafue Polder Meteorological station recorded the least linear trend value (-1.188) at 95% confidence level as presented in Table 4.7 below.

Table 4.7 : Linear Trend Values at 95% Confidence Level for Monthly Maximum Temperatures from 1982-2011

Name of Station	Highest Linear Trend Value	Lowest Linear Trend Value
Mumbwa	2.615	-0.674
Lusaka	2.521	-0.113

Kafue Polder	1.442	-1.188
Magoye	2.149	-0.618
Mt Makulu	2.616	-0.767

Source: Field work data, 2014.

Overall, the observed monthly maximum temperatures during 1982-2011 climate regime depicted increasing trends at different rates. For example, the months of August and October for Lusaka City show statistically significant trends (at a < 0.05 and a < 0.1 respectively) with increasing trends (See Table 7 in Appendix VI). Similarly, both August and October months for Magoye indicated statistically significant increasing trends at a < 0.05. Further, the month of October for Mumbwa and Kafue Polder showed statistically significant increasing trends at a < 0.01. Besides, the month of October for Mt Makulu exhibited statistically significant increasing trends at a < 0.05. Ultimately, the month of October depicted statistically significant increasing trends for all the Meteorological stations (See Table 7 in Appendix VI).

4.2.3.1.2 Analysis of Monthly Minimum Temperatures

Regarding monthly minimum temperatures, the highest Arithmetic mean for monthly minimum temperature over 1982-2011 climate regime was observed in March, November and June for some of the meteorological stations (22.4300°C for Magoye, 18.7233°C for Kafue Polder, 18.3467°C for Mt Makulu, 17.8833°C for Mumbwa and 17.8800°C for Lusaka City) whereas the lowest Arithmetic mean monthly minimum temperature for the above mentioned climate regime was noted in the month of July for all the meteorological stations (10.3900 °C for Lusaka City, 9.0900°C for Mt Makulu, 7.8333°C for Mumbwa, 7.6667°C for Kafue Polder and 6.8900°C for Magoye). Henceforward, Magoye recorded the highest (22.4300°C) and lowest (6.8900°C) mean monthly minimum temperatures in the months of March and July respectively for the whole 30 year period climate regime. On the other hand, the highest and lowest covariance's recorded for monthly minimum temperatures over the 1982-2011 climate regime were 126.66 (Magoye) and 2.88 (Mumbwa and Kafue) as shown in Table 4.8 below.

Table 4.8 : Covariance Values for Monthly Minimum Temperatures from 1982-2011

Name of Station	Highest Covariance	Lowest Covariance
Mumbwa	19.89	2.88
Lusaka	14.43	3.60
Kafue Polder	28.66	2.88
Magoye	16.02	2.95

Mt Makulu	12.84	3.17

Source: Field work data, 2014.

Additionally, the calculated Mann Kendal (MK) values for monthly minimum temperatures for the entire 30 year climate regime also point out that certain months from all meteorological stations were either significant or non-significant. However, the rest of months not shown in the Table 4.9 below exhibited non-significant MK values for the entire 1982-2011 climate regime. Table 4.9 below provides some of the MK values that were noted to be significant and non-significant (also see Tables 1-5 in Appendix VI).

Table 4.9 : Mann Kendall Values for Monthly Minimum Temperatures from 1982-2011

Name of the Station	Mann Kendall Value	Level of Significance	Month
Mumbwa	0.241	Significant	June
Lusaka	0.131	Non-significant	August
Kafue Polder	-0.375 and -0.416	Significant	October and September
Magoye	0.251	Non-significant	January
Mt Makulu	0.223	Significant	January

Source: Field work data, 2014.

Meanwhile the highest and lowest magnitude of change for monthly minimum temperatures observed were 0.0659 (Magoye) and -0.0876 (Kafue Polder) as shown in Table 4.10 below. The decadal changes recorded for all meteorological stations are shown in Table 1-5 in Appendix VI.

Table 4.10 : Magnitude of Change for Monthly Minimum Temperatures from 1982-2011

Name of Station	Highest Magnitude of Change	Lowest Magnitude of Change
Mumbwa	0.0624	-0.0034
Lusaka	0.0281	-0.0317

Kafue Polder	0.0024	-0.0876
Magoye	0.0659	-0.0443
Mt Makulu	0.0299	-0.0326

Source: Field work data, 2014.

With reference to linear trend values for monthly minimum temperatures, Mt Makulu Meteorological station recorded the steepest trend (2.381) while Magoye Meteorological station recorded the least linear trend value (-3.636) at 95% confidence level as shown in Table 4.11 below.

Table 4.11 : Linear Trend Values at 95% Confidence Level for Monthly Minimum Temperatures from 1982-2011

Name of Station	Highest Linear Trend Value	Lowest Linear Trend Value
Mumbwa	2.180	-0.775
Lusaka	1.963	-1.235
Kafue Polder	0.141	-3.795
Magoye	0.659	-3.636
Mt Makulu	2.381	-1.194

Source: Field work data, 2014.

Above and Beyond, trend analysis of minimum temperatures for the entire 1982-2011 period depicted both increasing and decreasing trends. For instance, the month of October for both Lusaka and Kafue Polder showed statistically significant increasing trends at $a < 0.05$ as shown in Table 8 in Appendix VI. Similarly, the months of January and February for Mt Makulu and Magoye depicted statistically significant increasing trends at $a < 0.05$. Moreover, the month of June for both Mumbwa and Kafue Polder displayed statistically significant increasing trends at $a < 0.05$ whereas the month of June for Magoye exhibited statistically significant increasing trends at $a < 0.1$(See Table 8 in Appendix VI). Further, both September and November months for Kafue Polder showed statistically significant decreasing trends at $a < 0.01$ and $a < 0.1$ respectively (See Table 8 in Appendix VI). In general, the observed minimum temperatures for all the Meteorological stations give evidence of upward and downward trends during the 30 year period.

4.2.3.1.3 Analysis of Seasonal Maximum Temperatures

Maximum temperatures in the Kafue eco-region vary from 20°C to 35.6°C, depending on the season. As can be seen from the Excel Sheet in Appendix VII, SON generally has the highest average annual seasonal maximum temperatures for all Meteorological stations i.e.35.56667 °C in 2005 (Mumbwa), 33.7°C in 1999 (Kafue Polder), 33.66667°C in 1998 (Magoye), 32.36667°C in 2005(Mt Makulu and 31.46667°C in 1998 (Lusaka City). Notably, the highest average annual seasonal maximum temperature observed in this study was 35.56667 °C in 2005 (Mumbwa station) during the SON season. However, the lowest maximum temperatures were recorded during the JJA seasons for all the five Meteorological stations. Throughout all the three ecological zones (regions) of Zambia, the highest temperatures are basically recorded in SON (summer) with the lowest temperatures recorded in JJA season (winter). Nevertheless, there were slight variations in the maximum temperatures recorded during MAM and DJF seasons; the values were nearly close to those in the SON season for all the meteorological stations as shown in the Excel Sheet in Appendix VIII. Figure 4.24 to 4.43 for all the Meteorological stations depict downward and upward trends in the seasonal maximum temperatures recorded during the 1982-2011 climate regime.

With regards to trend analysis of seasonal maximum temperatures, different seasons showed statistically significant increasing trends at different rates as shown in Table 4.12 below. For example, JJA and SON seasons for Lusaka City exhibited statistically significant increasing trends at a < 0.1 (See Table 4.12 below). Equally, SON seasons for Mt Makulu and Mumbwa portrayed statistically significant increasing trends at a < 0.1 and a < 0.05 respectively. However, all seasons for Kafue Polder and Magoye depicted increasing trends though not statistically significant at a = 0.10.

Table 4.12 : Trend values (z-statistic) for Seasonal Maximum Temperatures

Station	z-statistic for each season			
	MAM	JJA	SON	DJF
Lusaka city	0.714	**1.82**	**1.873**	0.535
Kafue Polder	-0.553	0.196	0.25	0.196
Mumbwa	0.321	1.641	**2.016**	1.213
Magoye	-0.196	0.642	1.356	0.393
Mt Makulu	-0.107	0.678	**1.695**	0.607

NB: Bold values show statistically significant trends (at a < 0.1 and a < 0.05) with increasing trends.

Source: Field work data, 2014.

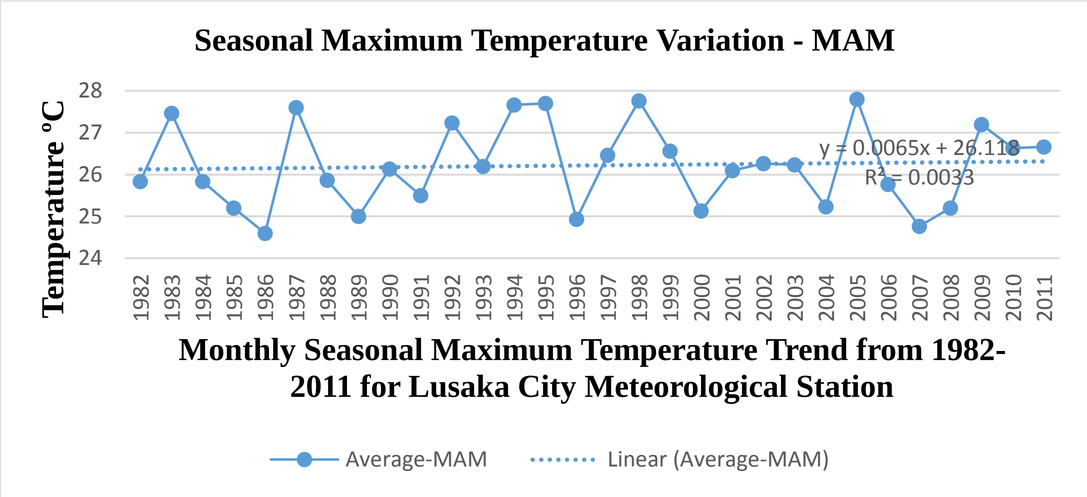

Figure 4.24 : Seasonal Maximum Temperature Average Trend (MAM) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

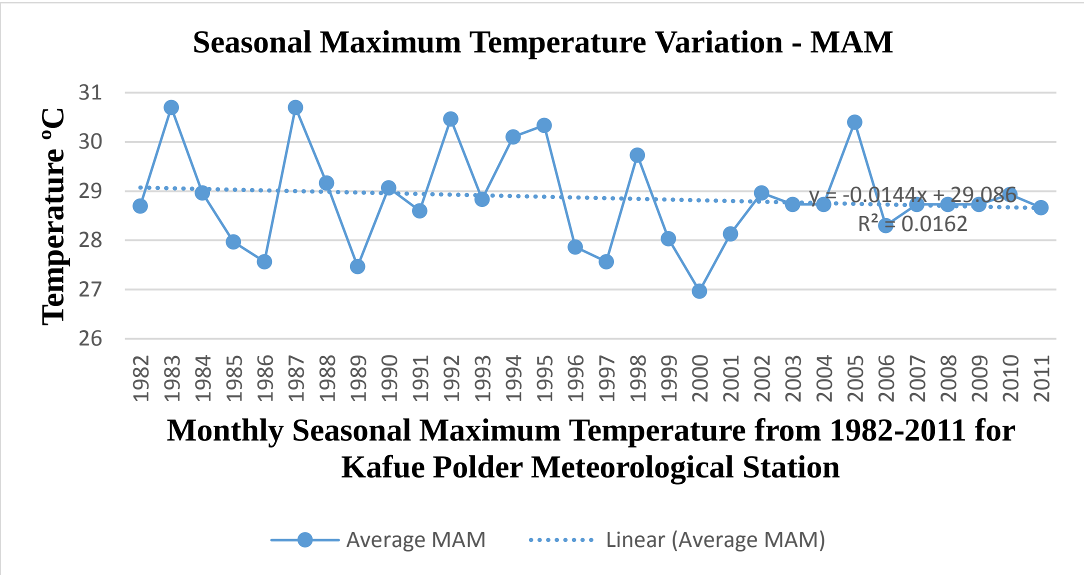

Figure 4.25 : Seasonal Maximum Temperature Average Trend (MAM) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

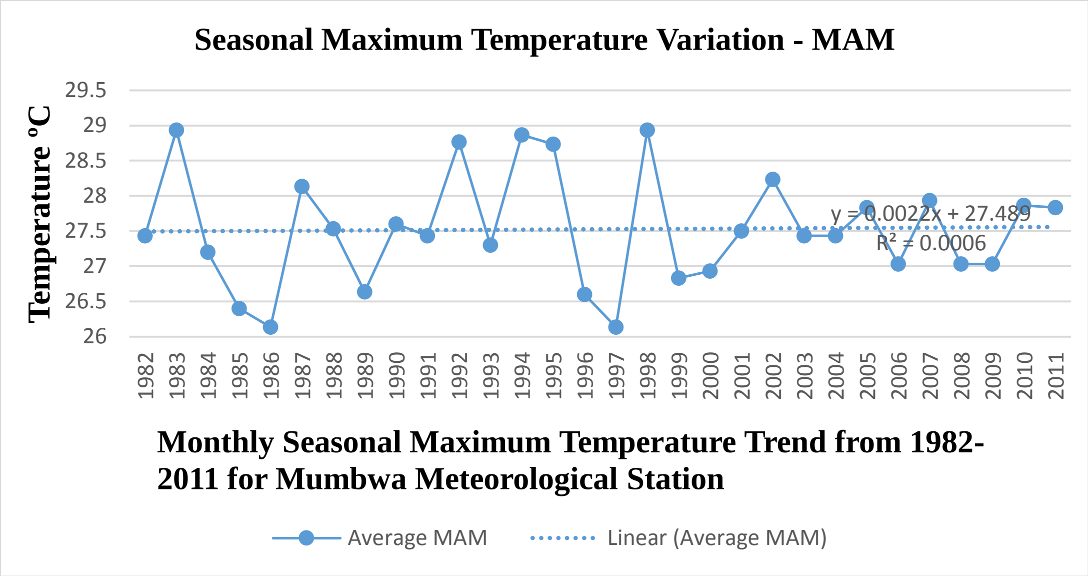

Figure 4.26 : Seasonal Maximum Temperature Average Trend (MAM) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

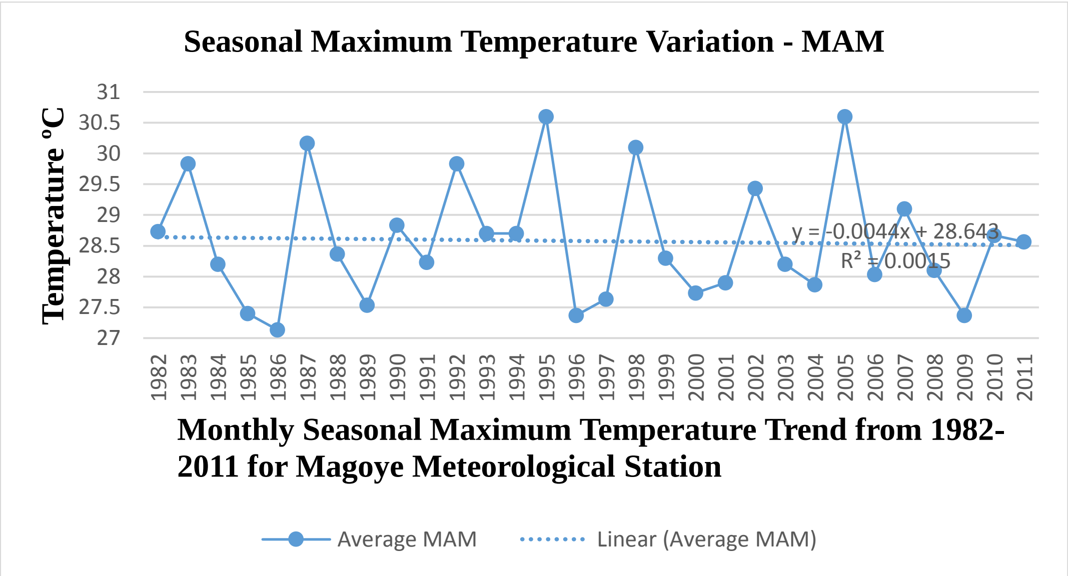

Figure 4.27 : Seasonal Maximum Temperature Average Trend (MAM) from 1982-2011 for Magoye.

Source: Field work data, 2014.

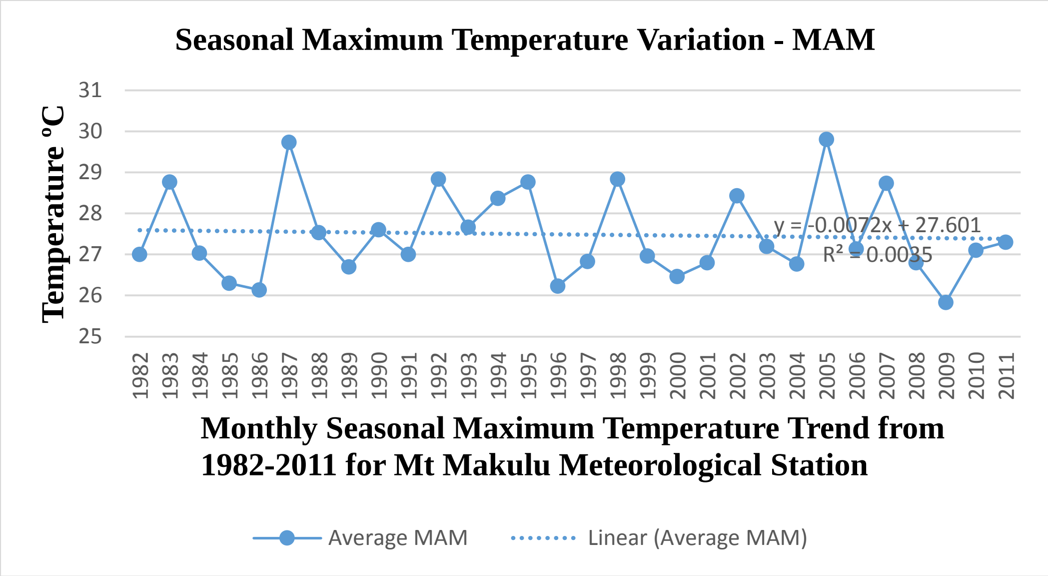

Figure 4.28 : Seasonal Maximum Temperature Average Trend (MAM) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

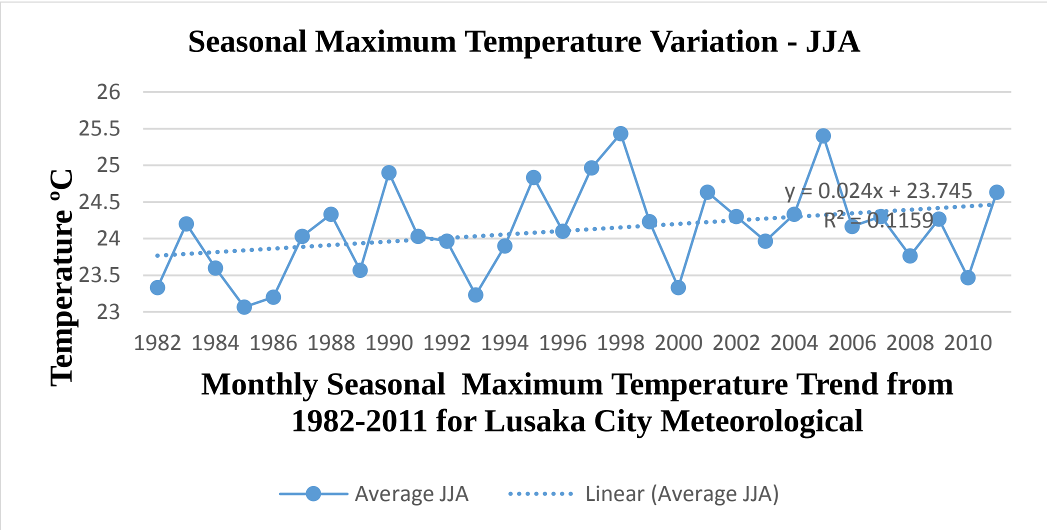

Figure 4.29 : Seasonal Maximum Temperature Average Trend (JJA) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

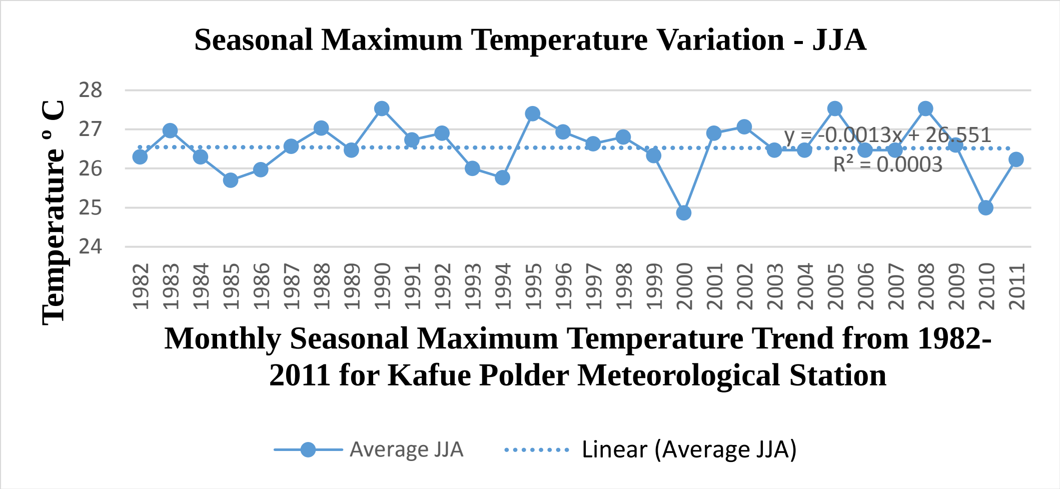

Figure 4.30 : Seasonal Maximum Temperature Average Trend (JJA) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

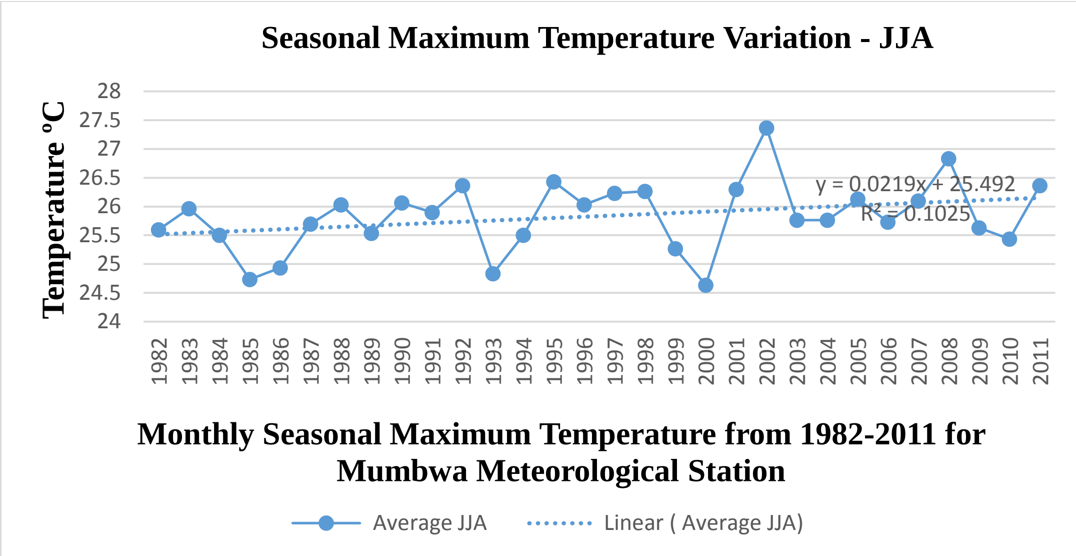

Figure 4.31 : Seasonal Maximum Temperature Average Trend (JJA) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

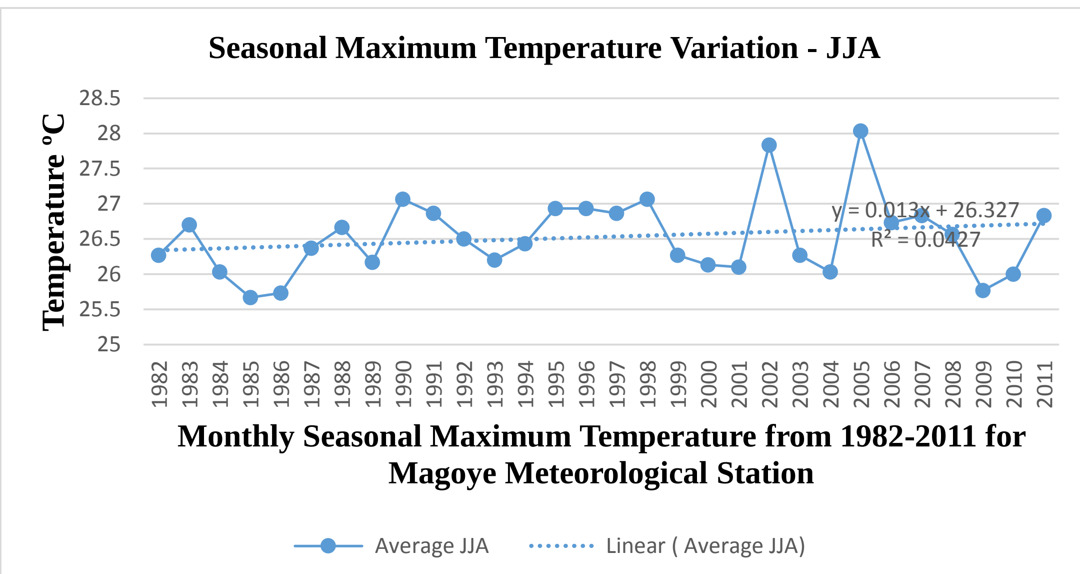

Figure 4.32 : Seasonal Maximum Temperature Average Trend (JJA) from 1982-2011 for Magoye.

Source: Field work data, 2014.

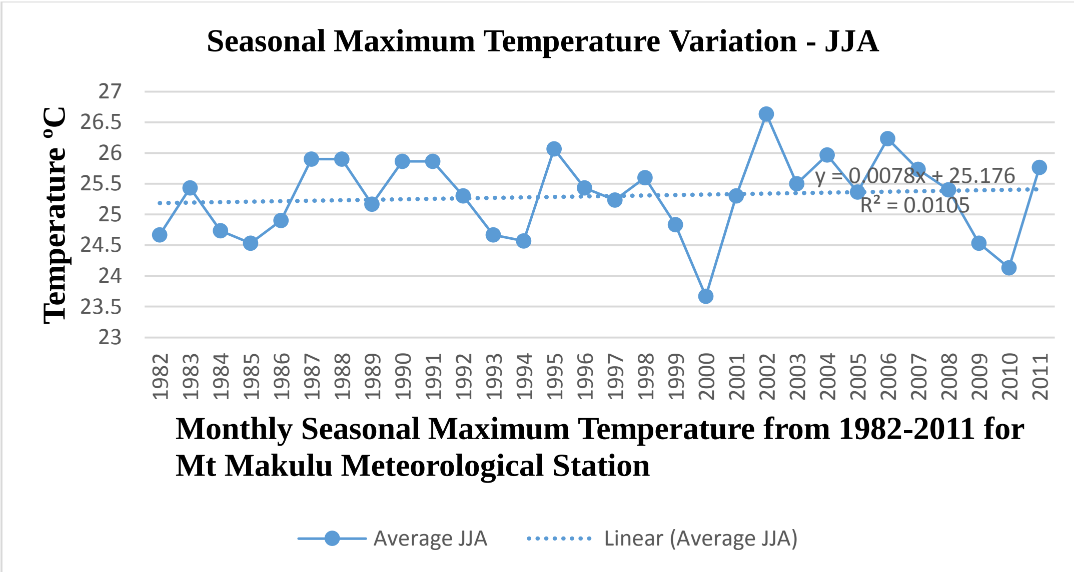

Figure 4.33 : Seasonal Maximum Temperature Average Trend (JJA) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

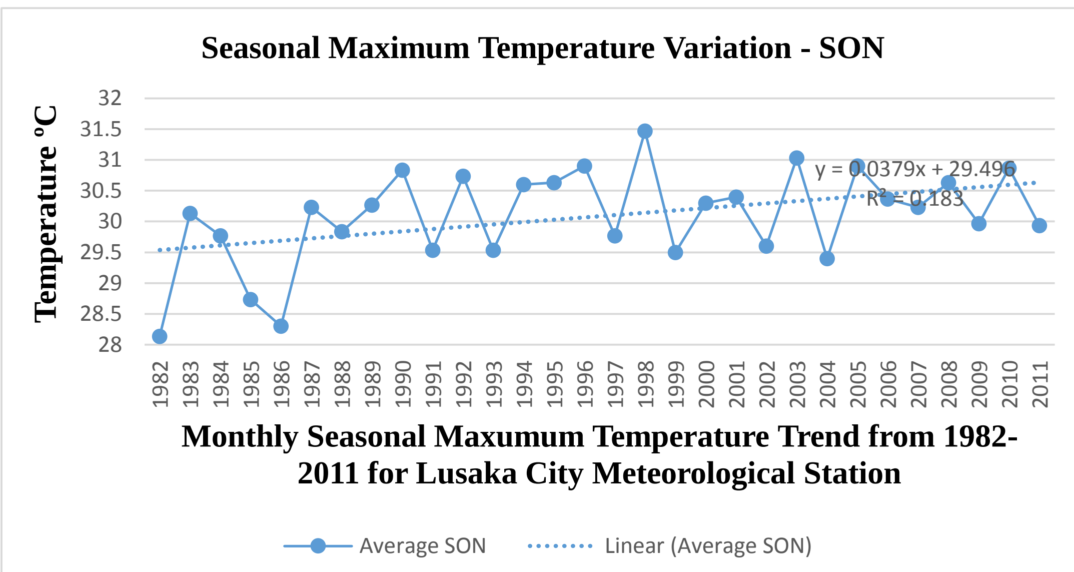

Figure 4.34 : Seasonal Maximum Temperature Average Trend (SON) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

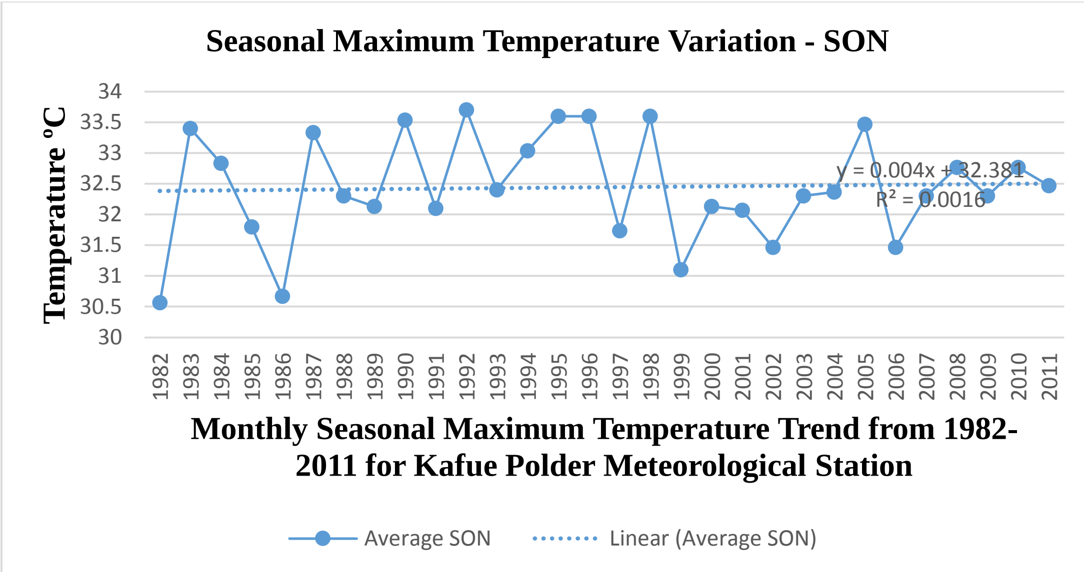

Figure 4.35 : Seasonal Maximum Temperature Average Trend (SON) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

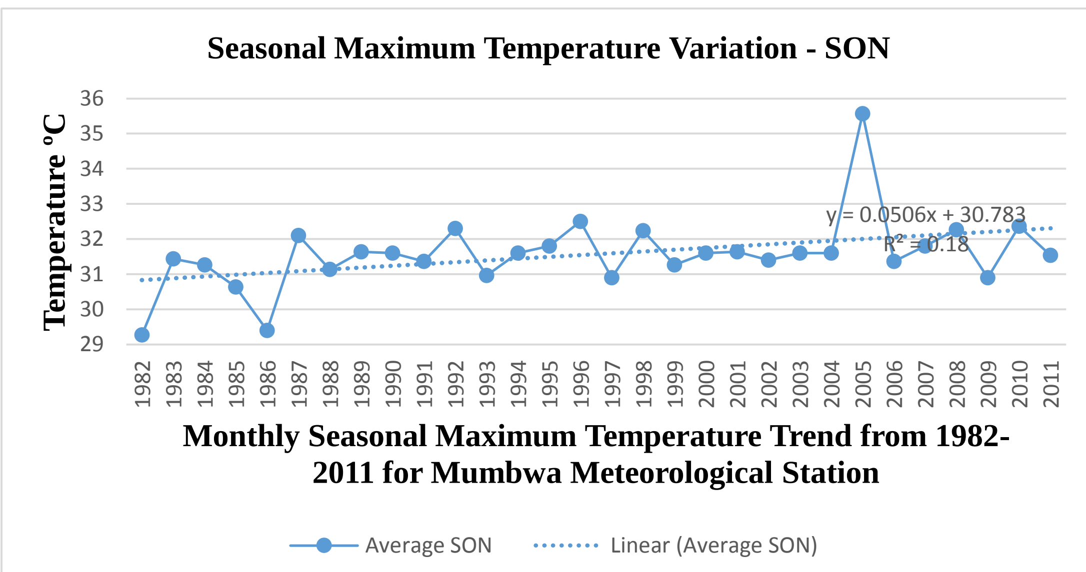

Figure 4.36 : Seasonal Maximum Temperature Average Trend (SON) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

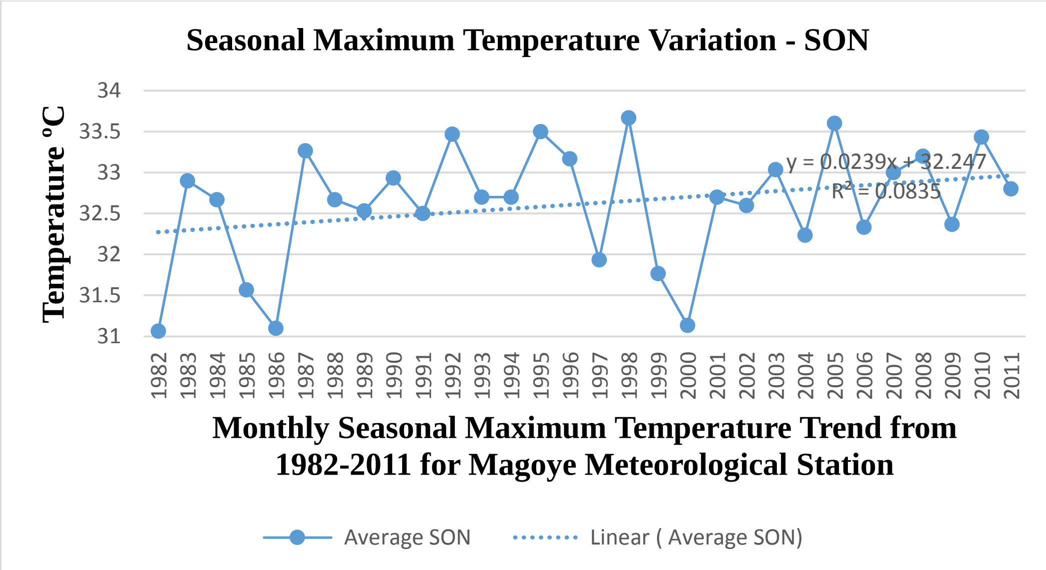

Figure 4.37 : Seasonal Maximum Temperature Average Trend (SON) from 1982-2011 for Magoye.

Source: Field work data, 2014.

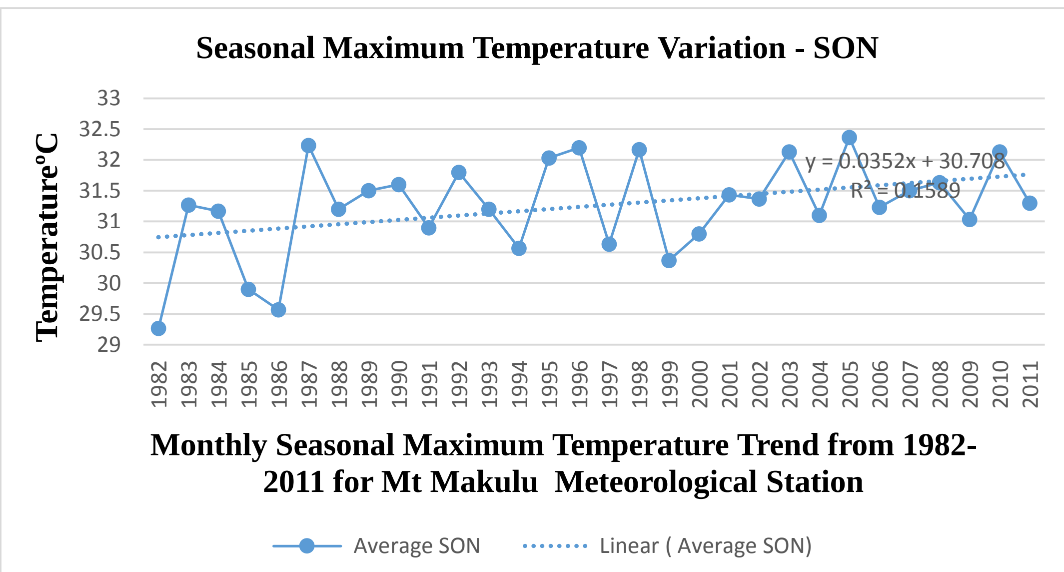

Figure 4.38 : Seasonal Maximum Temperature Average Trend (SON) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

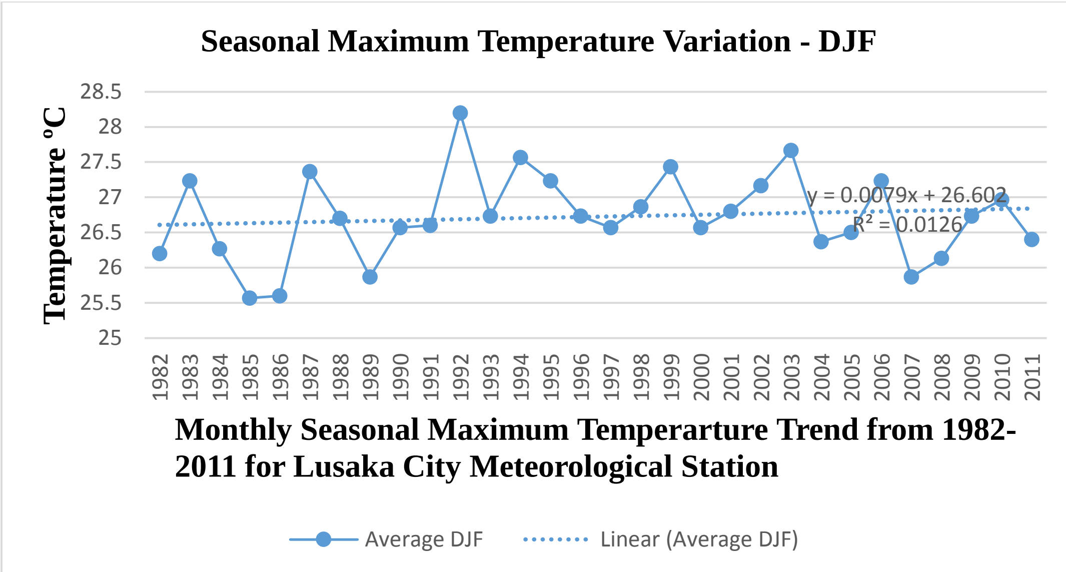

Figure 4.39 : Seasonal Maximum Temperature Average Trend (DJF) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

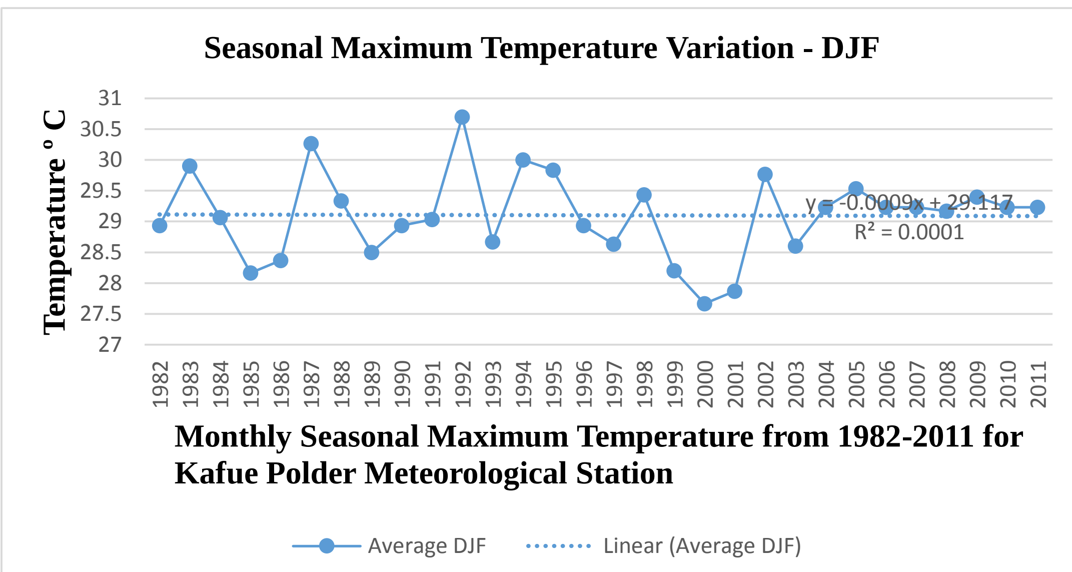

Figure 4.40 : Seasonal Maximum Temperature Average Trend (DJF) from 1982-2011 for Kafue polder.

Source: Field work data, 2014.

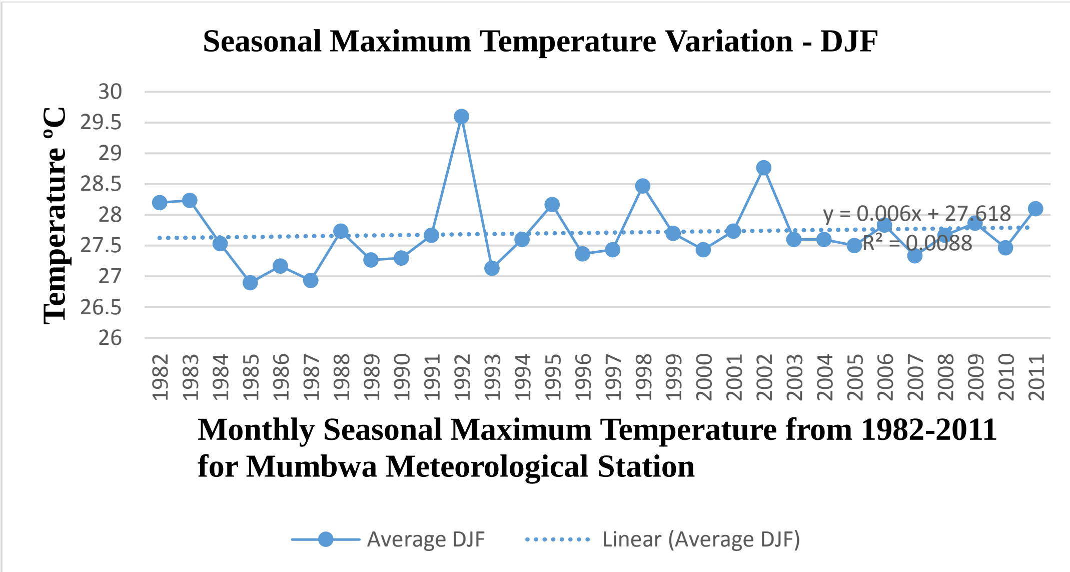

Figure 4.41 : Seasonal Maximum Temperature Average Trend (DJF) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

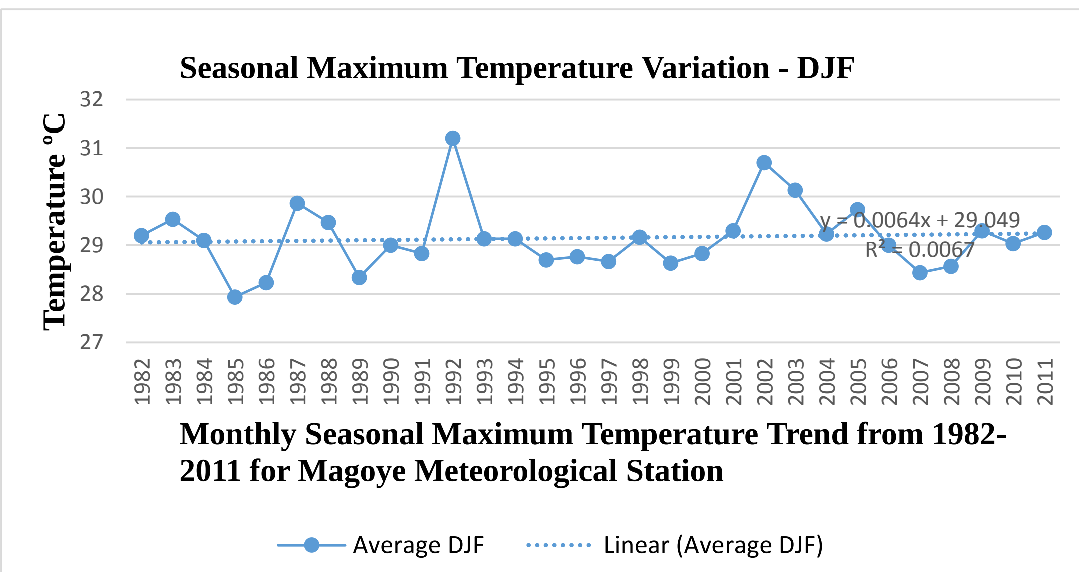

Figure 4.42 : Seasonal Maximum Temperature Average Trend (DJF) from 1982-2011 for Magoye.

Source: Field work data, 2014.

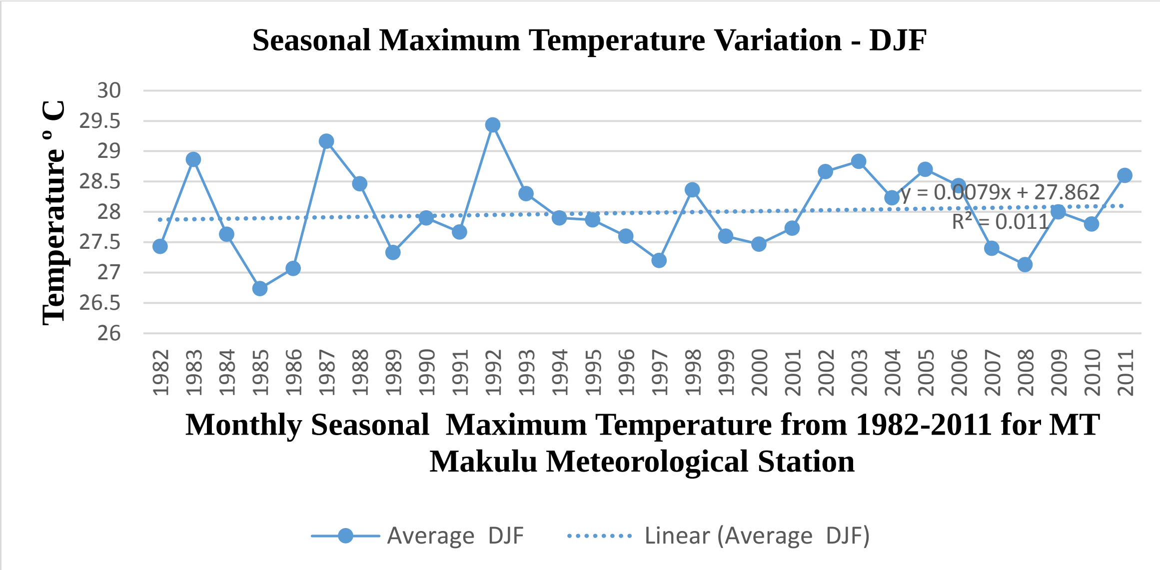

Figure 4.43 : Seasonal Maximum Temperature Average Trend (DJF) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

4.2.3.1.4 Analysis of Seasonal Minimum Temperatures

Minimum temperatures in the Kafue eco-region vary from 5.7 °C to 19.7 °C depending on the season as shown in the Excel Sheet in Appendix IX. The highest mean annual seasonal minimum temperature recorded for the whole 1982-2011 period was 19.7°C in 2004 at Magoye Meteorological station during the DJF season. The seasonal trend analysis of the minimum temperatures indicates that both SON and DJF seasons had relatively higher mean seasonal minimum temperatures for all the Meteorological stations. However, the lowest mean seasonal minimum temperatures were observed during the JJA season i.e. Kafue Polder recorded 5.7°C in 2011 during the JJA season as the lowest mean seasonal minimum temperature over the 1982-2011 climate regime (See Excel sheet in Appendix IX). MAM season for all the Meteorological had slightly higher minimum temperatures compared to JJA season. Overall, there are differences in seasonal distributions of minimum temperatures. Most of the seasons depicted positive and negative trends though not statistically significant (See figure 4.44 to 4.63 below). Interestingly, some seasons showed statistically significant increasing and decreasing trends. For example, SON season for Kafue Polder depicted statistically significant decreasing trend at a < 0.01(See Table 4.13 below). Moreover, DJF season for Magoye and Mt Makulu exhibited statistically significant increasing trend at a < 0.05 as shown in Table 4.13 below. However, all the four seasons for Lusaka City and Mumbwa showed no statistically significant trends at a = 0.10. Although the causes for differences in mean monthly and seasonal temperature trends were not established in this study, use of general circulation models could perhaps explain the causes further.

Table 4.13 : Trend values (z-statistic) for Seasonal Minimum Temperatures.

Station	z-statistic for each season			
	MAM	JJA	SON	DJF
Lusaka city	-0.214	0.607	0.749	-0.161
Kafue Polder	-1.427	-1.374	**-2.908**	0.357
Mumbwa	0.963	1.588	0.143	0.66
Magoye	-0.749	1.499	0.535	**2.64**
Mt Makulu	0.018	-0.963	0	**2.159**

NB: Bold values show statistically significant trends (at a < 0.01 and a < 0.05) increasing and decreasing.

Source: Field work data, 2014.

Figure 4.44 to 4.63 below show seasonal trends for minimum temperatures for the five Meteorological stations.

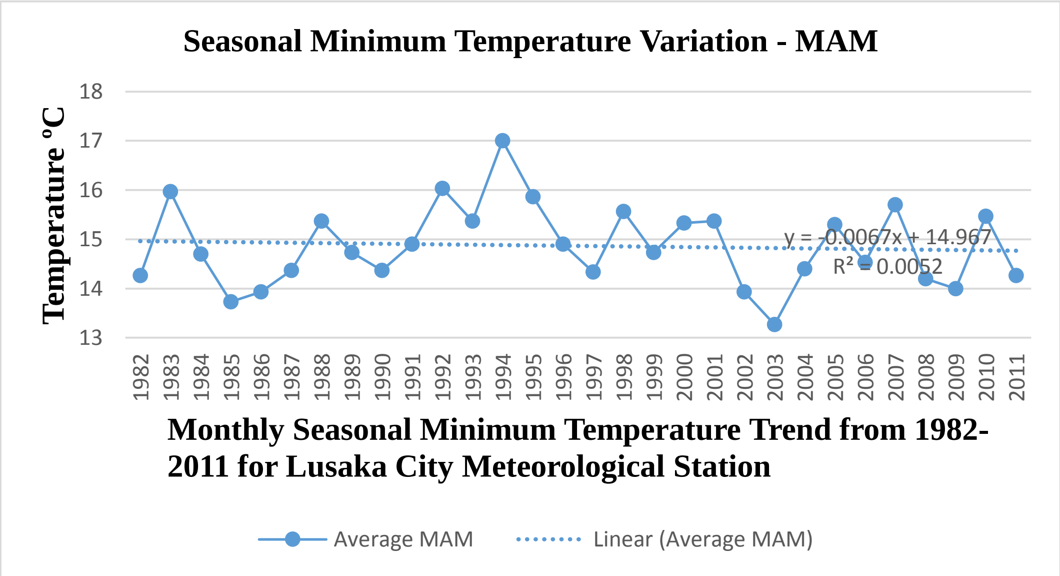

Figure 4.44 : Seasonal Minimum Temperature Average Trend (MAM) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

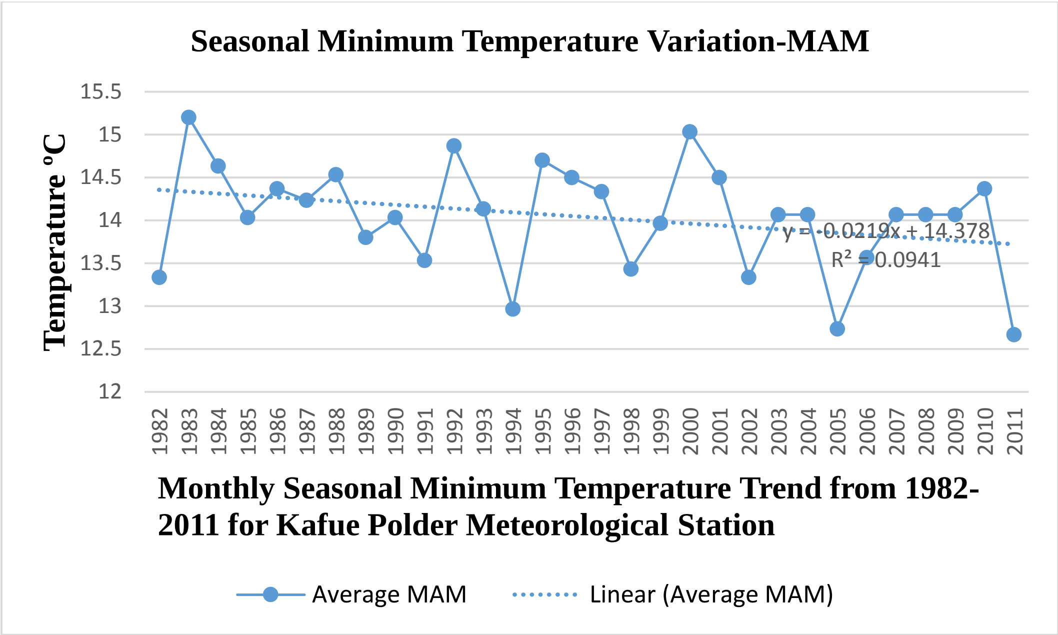

Figure 4.45 : Seasonal Minimum Temperature Average Trend (MAM) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

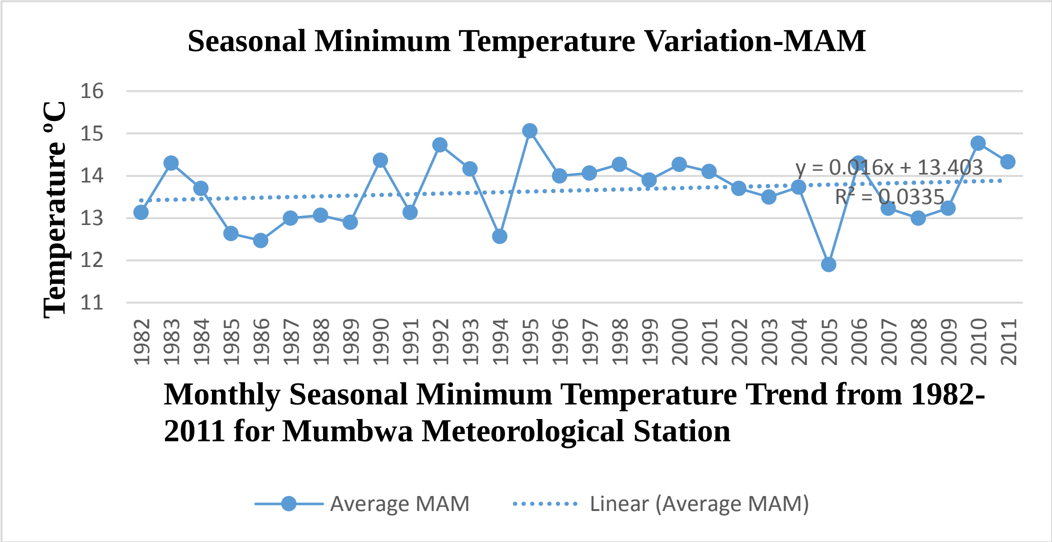

Figure 4.46 : Seasonal Minimum Temperature Average Trend (MAM) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

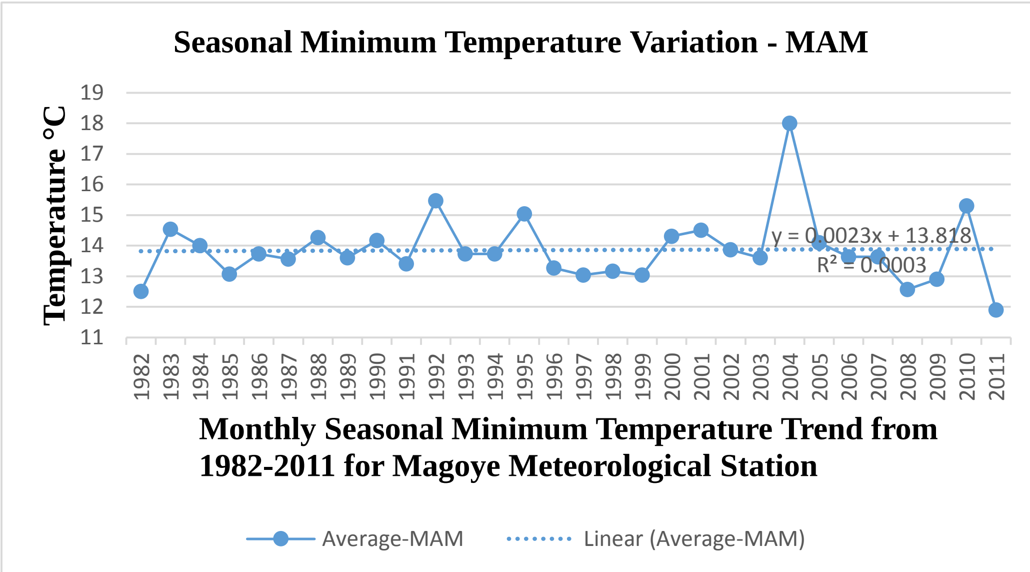

Figure 4.47 : Seasonal Minimum Temperature Average Trend (MAM) from 1982-2011 for Magoye.

Source: Field work data, 2014.

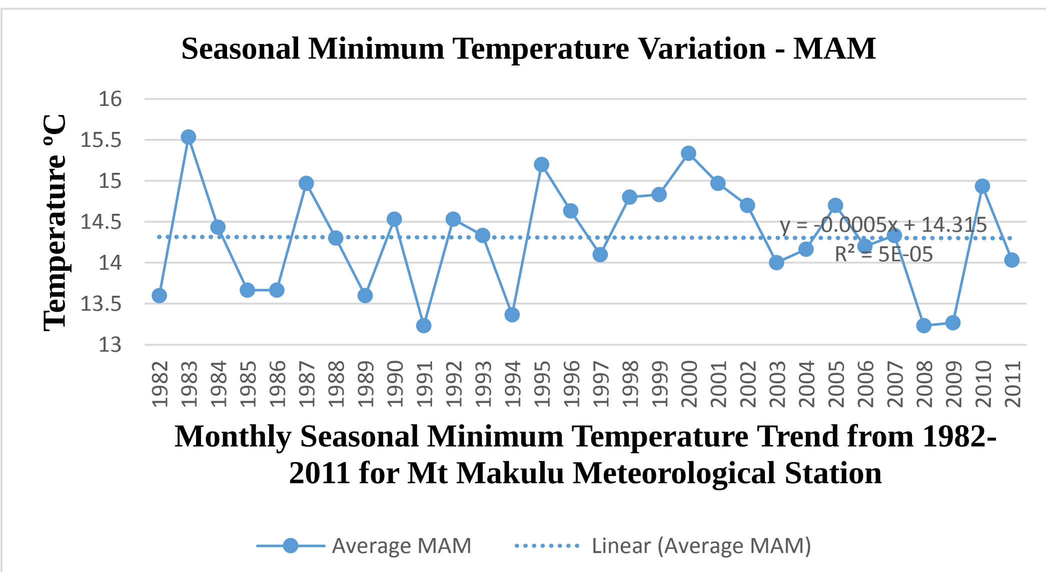

Figure 4.48 : Seasonal Minimum Temperature Average Trend (MAM) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

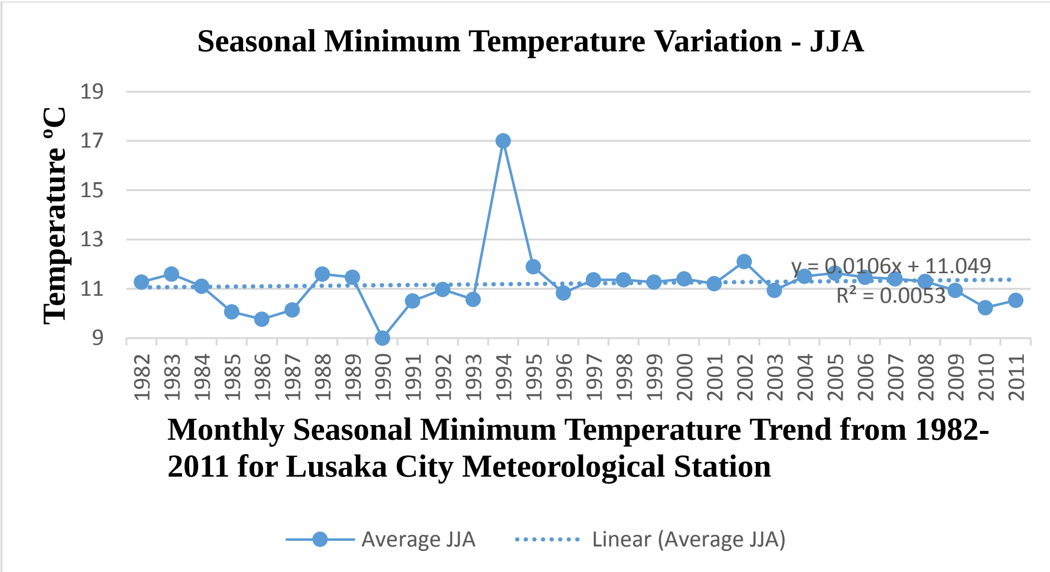

Figure 4.49 : Seasonal Minimum Temperature Average Trend (JJA) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

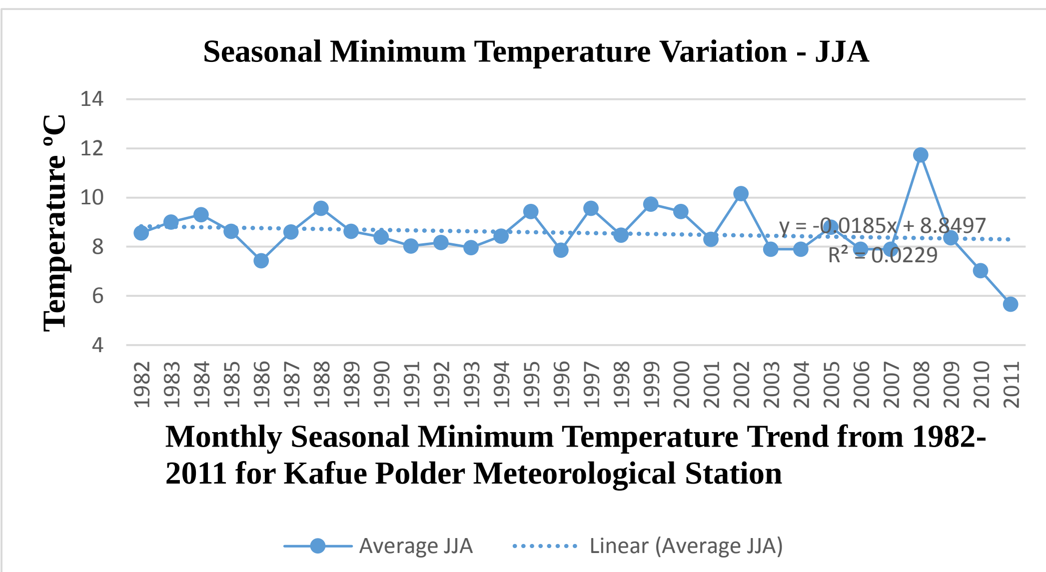

Figure 4.50 : Seasonal Minimum Temperature Average Trend (JJA) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

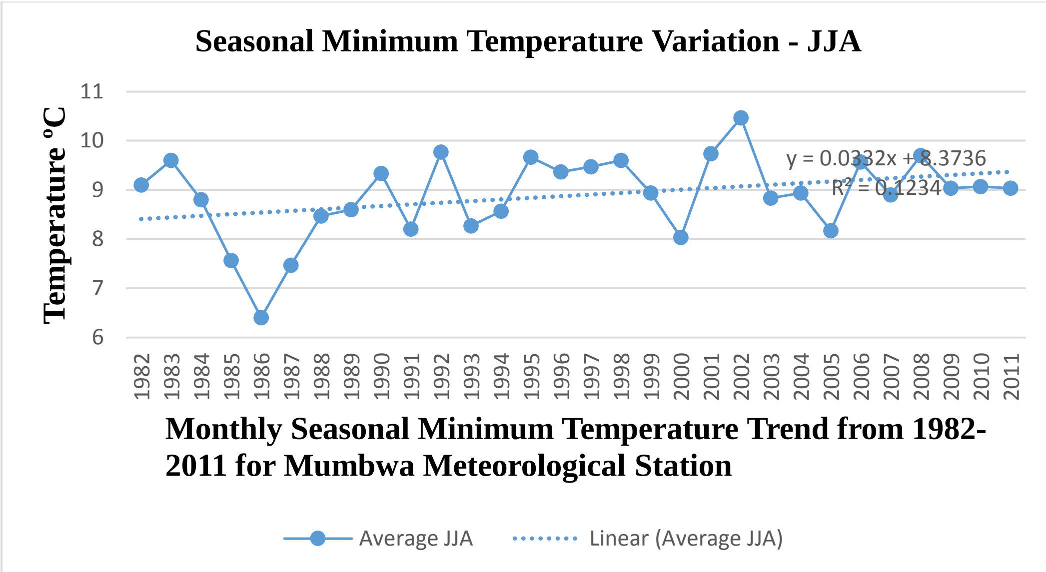

Figure 4.51 : Seasonal Minimum Temperature Average Trend (JJA) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

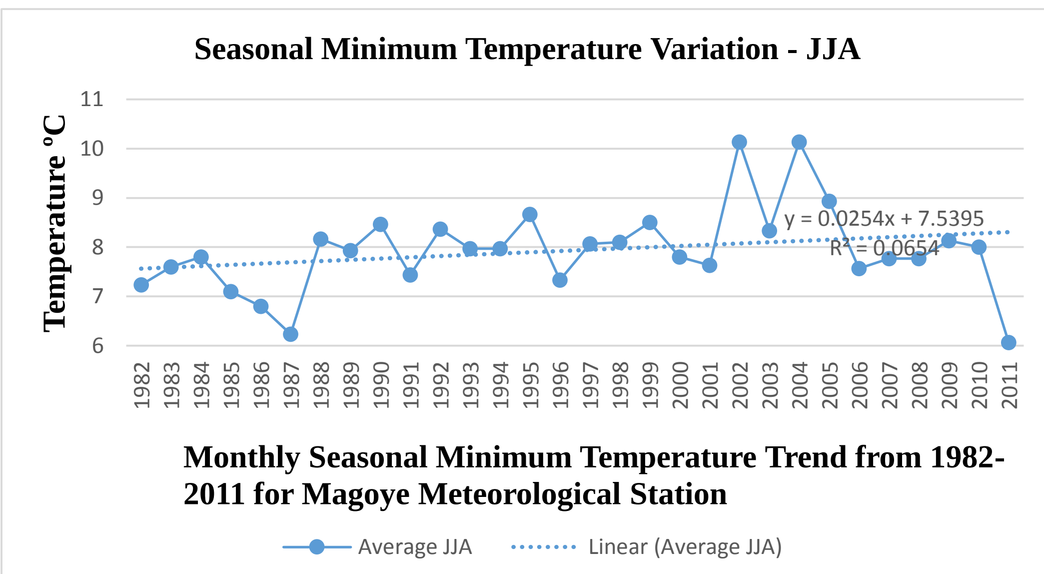

Figure 4.52 : Seasonal Minimum Temperature Average Trend (JJA) from 1982-2011 for Magoye.

Source: Field work data, 2014.

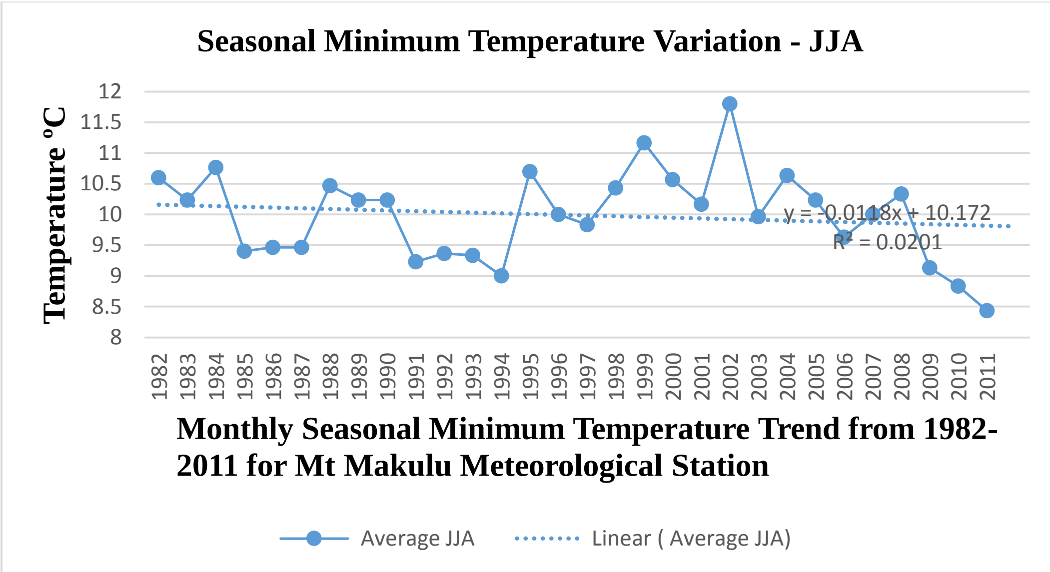

Figure 4.53 : Seasonal Minimum Temperature Average Trend (JJA) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

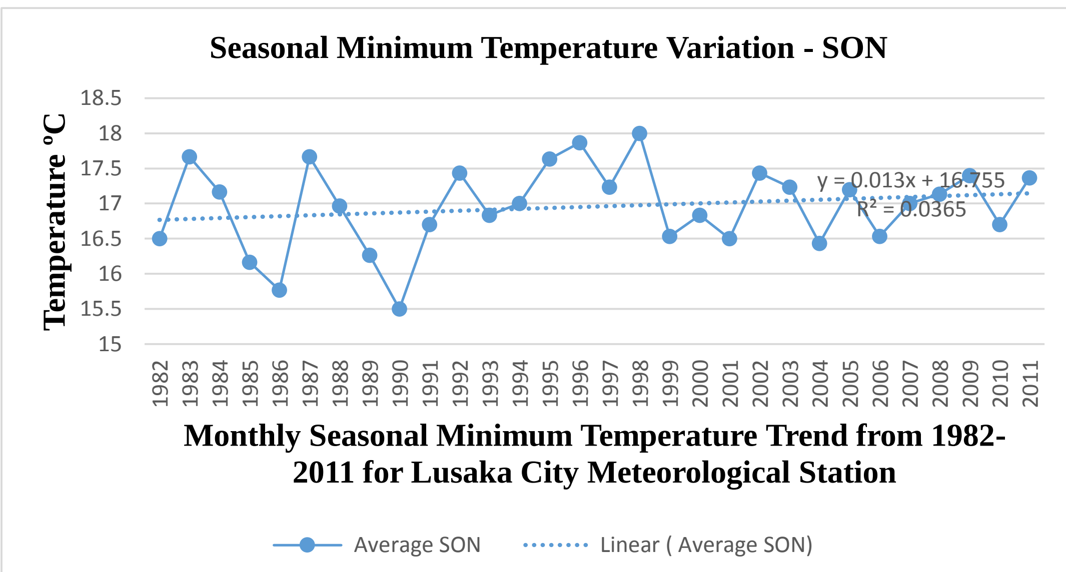

Figure 4.54 : Seasonal Minimum Temperature Average Trend (SON) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

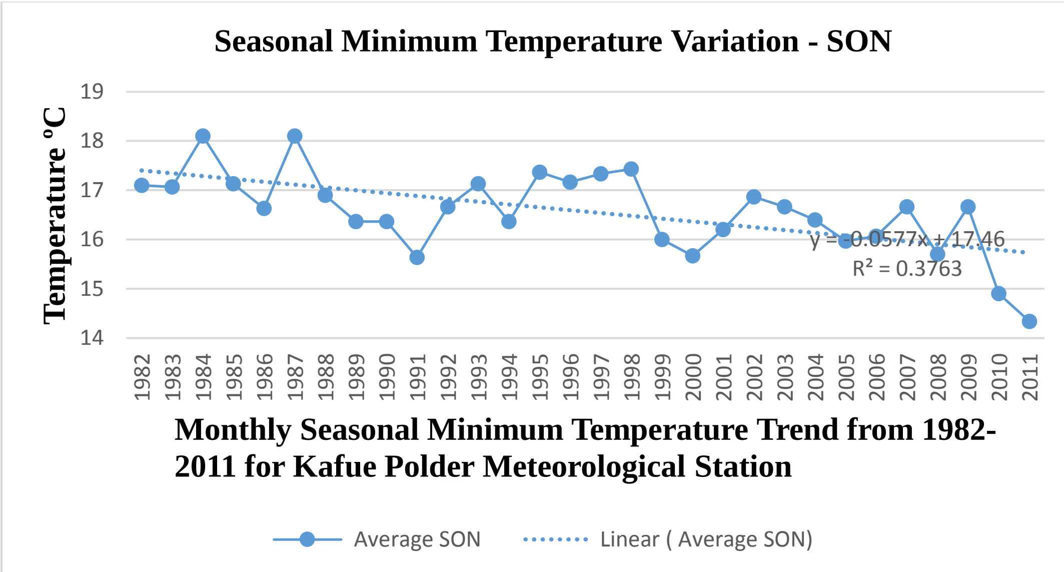

Figure 4.55 : Seasonal Minimum Temperature Average Trend (SON) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

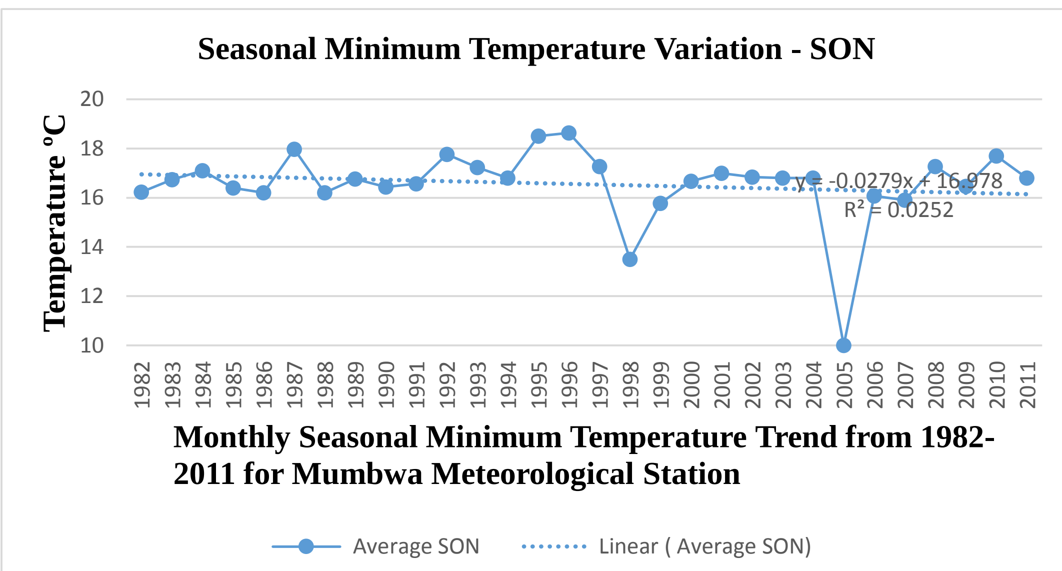

Figure 4.56 : Seasonal Minimum Temperature Average Trend (SON) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

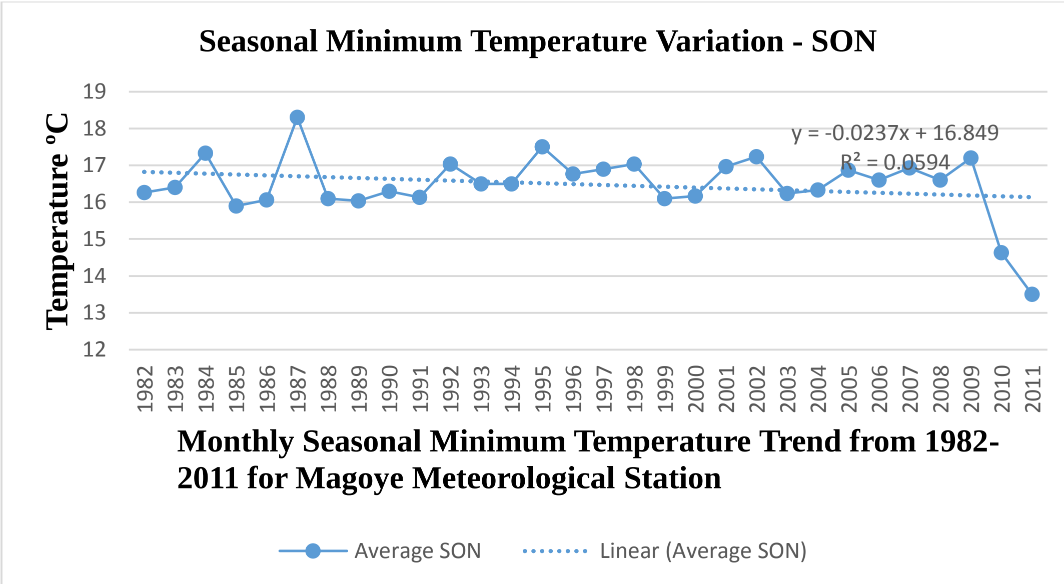

Figure 4.57 : Seasonal Minimum Temperature Average Trend (SON) from 1982-2011 for Magoye.

Source: Field work data, 2014.

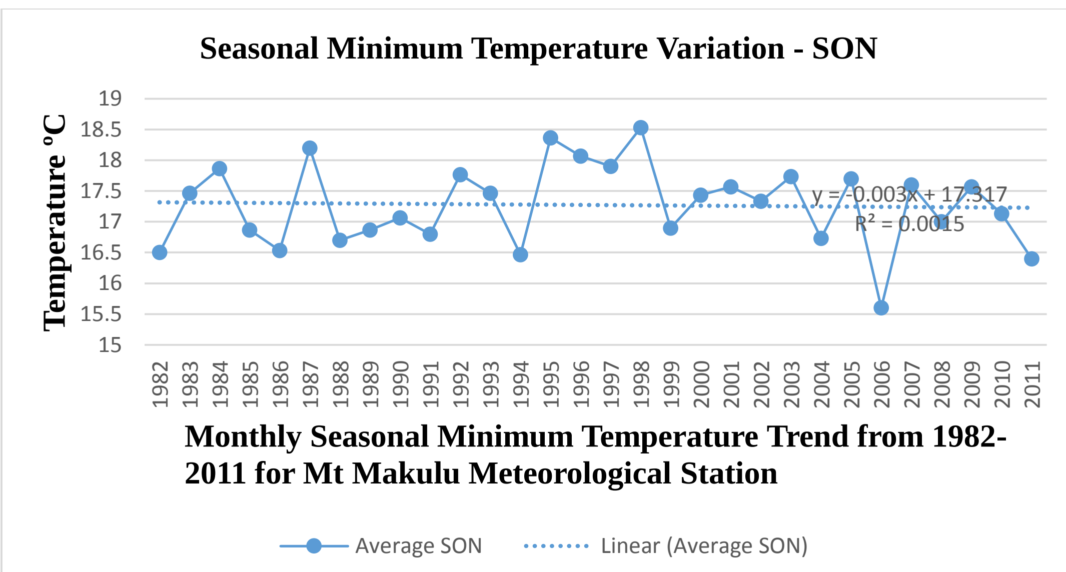

Figure 4.58 : Seasonal Minimum Temperature Average Trend (SON) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

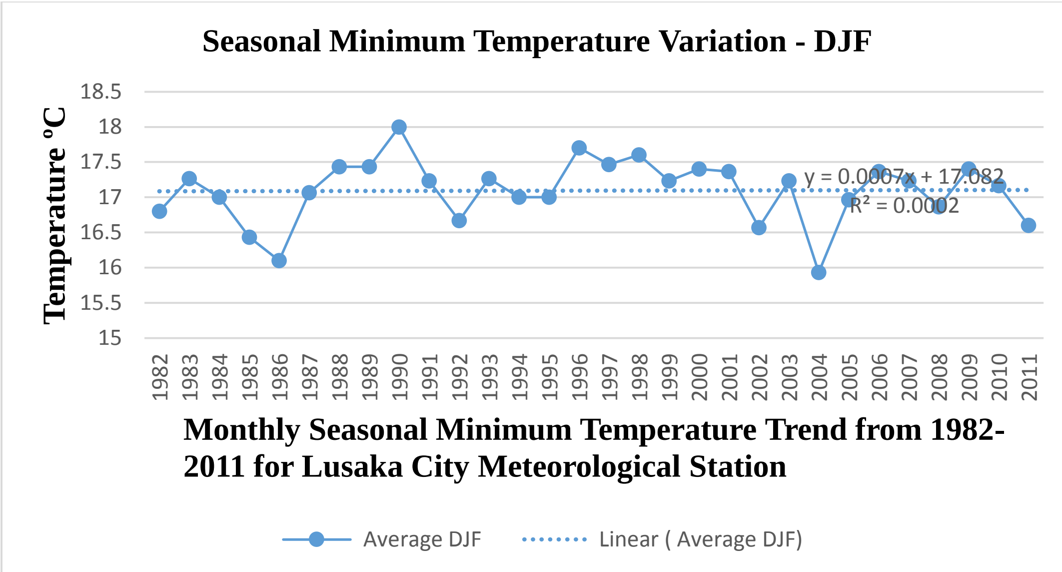

Figure 4.59 : Seasonal Minimum Temperature Average Trend (DJF) from 1982-2011 for Lusaka City.

Source: Field work data, 2014.

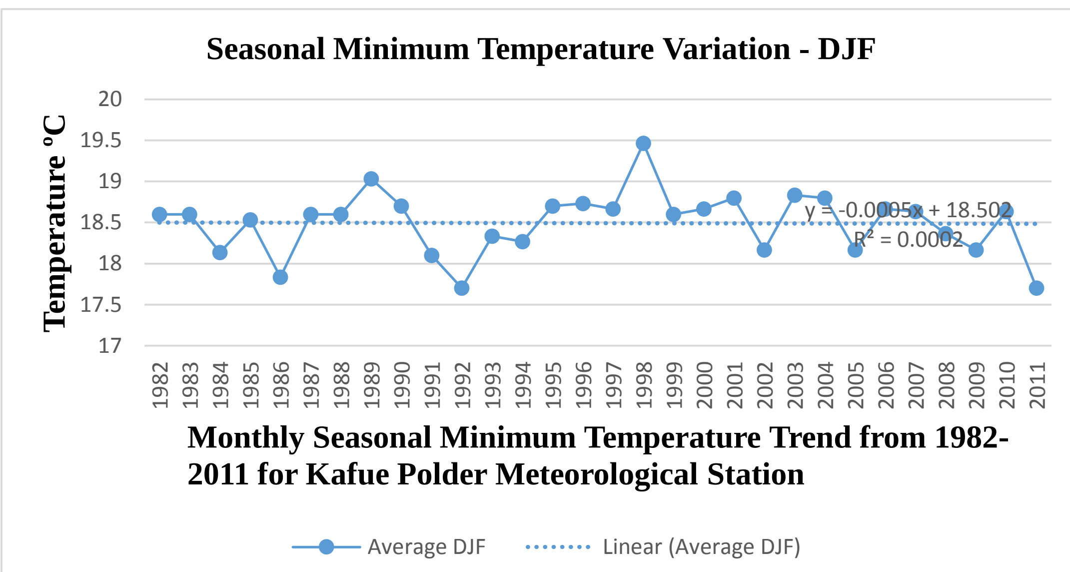

Figure 4.60: Seasonal Minimum Temperature Average Trend (DJF) from 1982-2011 for Kafue Polder.

Source: Field work data, 2014.

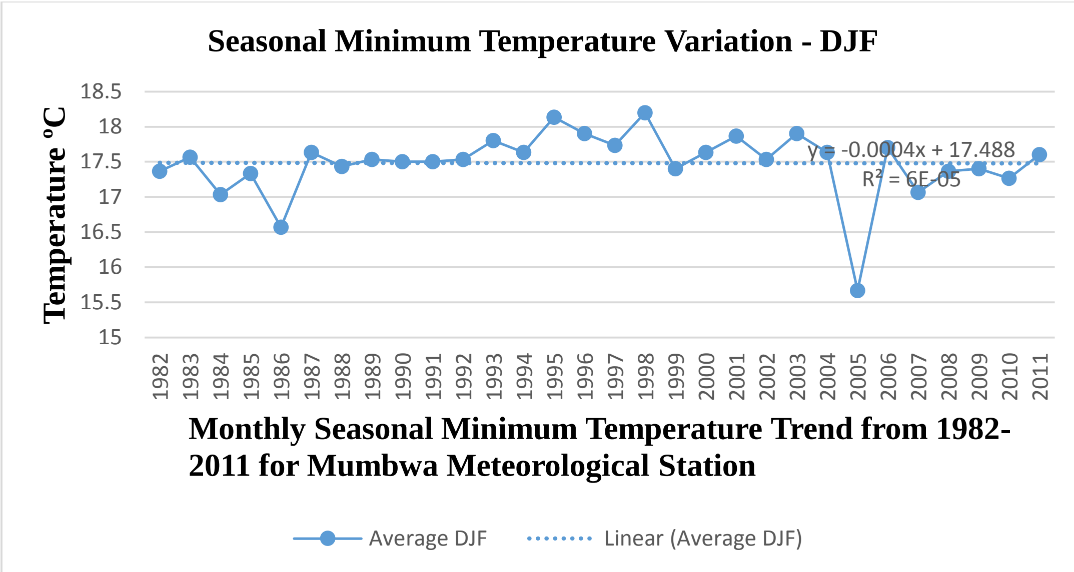

Figure 4.61 : Seasonal Minimum Temperature Average Trend (DJF) from 1982-2011 for Mumbwa.

Source: Field work data, 2014.

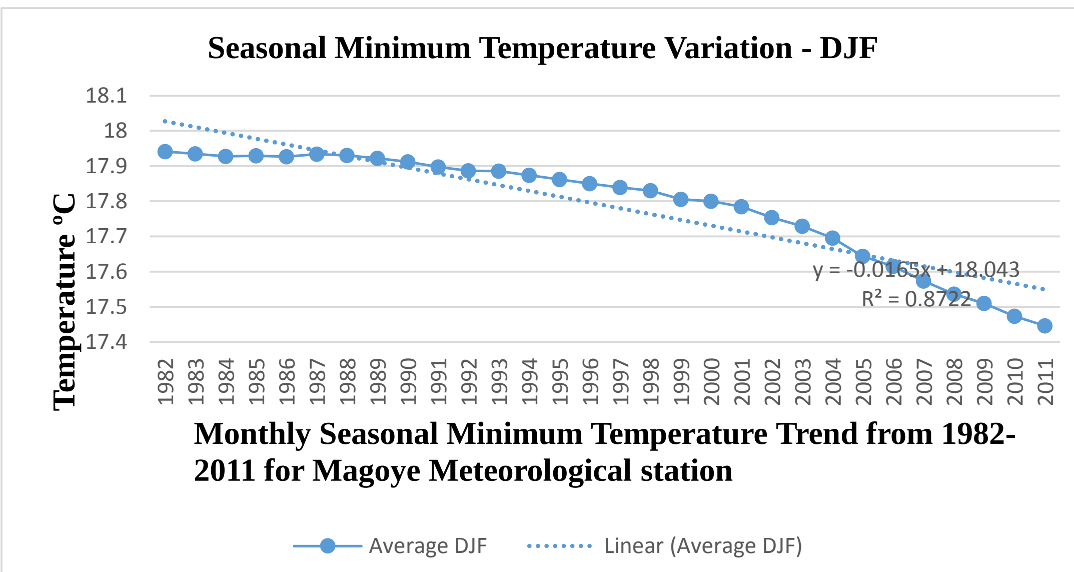

Figure 4.62 : Seasonal Minimum Temperature Average Trend (DJF) from 1982-2011 for Magoye.

Source: Field work data, 2014.

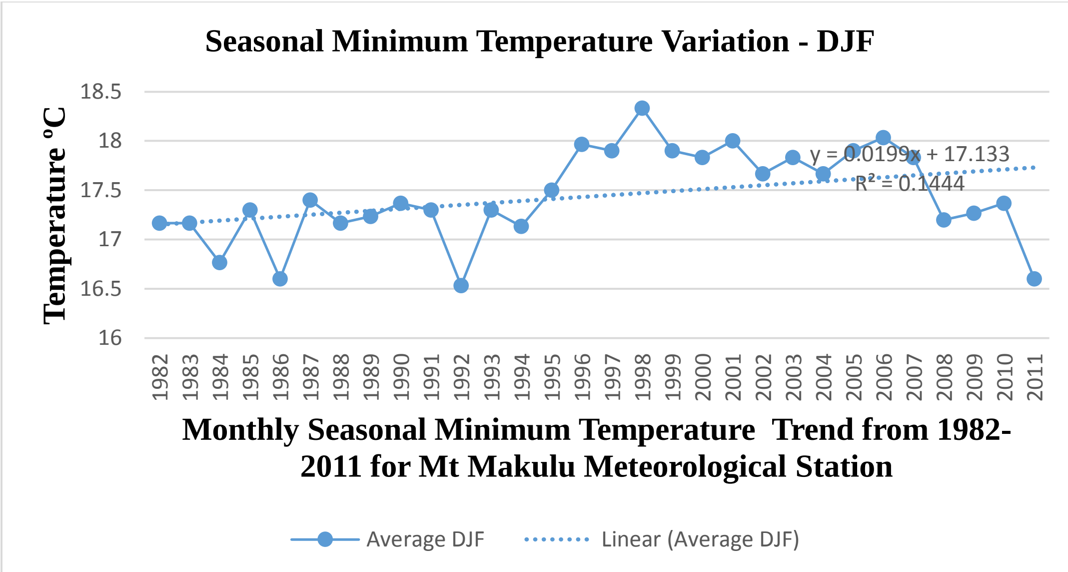

Figure 4.63 : Seasonal Minimum Temperature Average Trend (DJF) from 1982-2011 for Mt Makulu.

Source: Field work data, 2014.

4.2.3.2 Annual Maximum and Minimum Temperatures

4.2.3.2.1 Annual Maximum Temperatures

Analysis of average annual maximum temperatures indicate that there is only a slight variation in maximum temperatures for all the stations throughout the 1982-2011 period. Magoye Meteorological station recorded the highest maximum temperature of 30.5ºC in 2005 during the entire 1982-2011 period as shown in figure 4.64 below. Meanwhile, Lusaka City recorded the lowest maximum temperatures of 25.4 ºC in 1986.

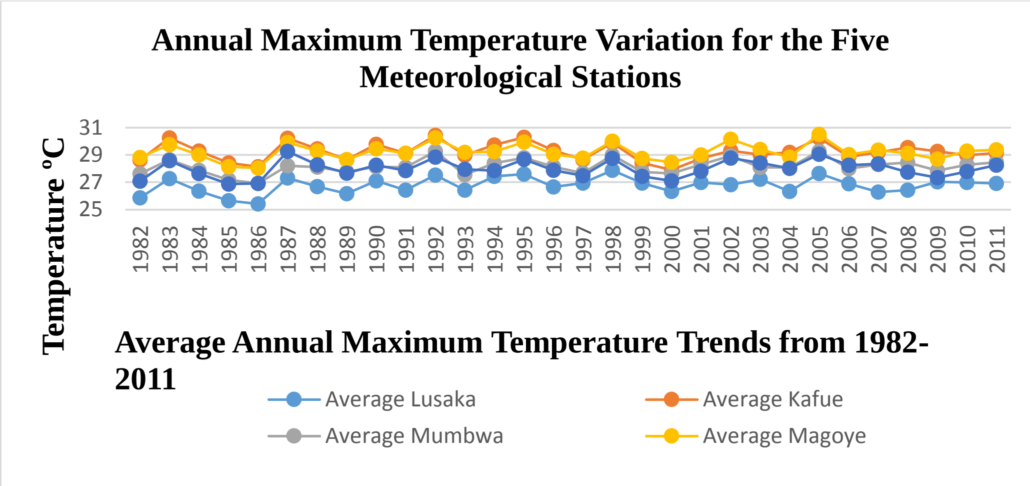

Figure 4.64 : Average Annual Maximum Temperatures.

Source: Field work data, 2014.

By and large, trend analysis of annual maximum temperatures for the Kafue Flats depicted increasing trends. The annual maximum temperatures had been changing at a rate of 0.0113 per annum during the 1982-2011 period (See figure 4.65 below). However, the observed trends in mean annual maximum temperature are not statistically significant at a = 0.10 with z-statistic of 0.963.

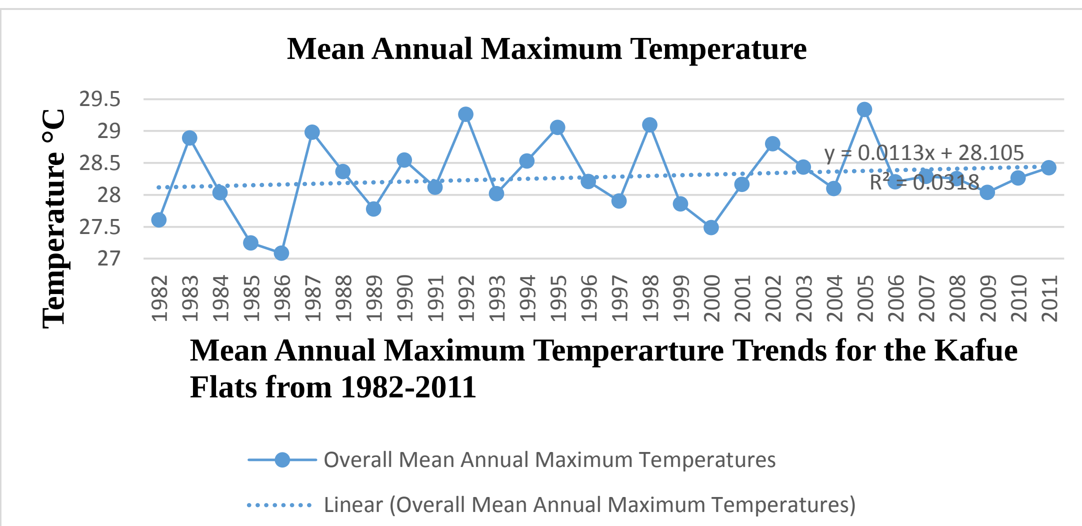

Figure 4.65 : Average Annual Maximum Temperatures for the Kafue Flats.

Source: Field work data, 2014

4.2.3.2.2 Annual Minimum Temperatures

Analysis of average annual minimum temperatures indicate little variation in minimum temperatures for all Meteorological stations. Most of the Meteorological stations recorded almost the same values throughout the 1982-2011 period as shown in figure 4.66 below. However, Magoye recorded the highest average annual minimum temperature of 26.8ºC in 1991. Meanwhile Mumbwa recorded the lowest average annual minimum temperature of 11.4 ºC as shown in figure 4.66 below.

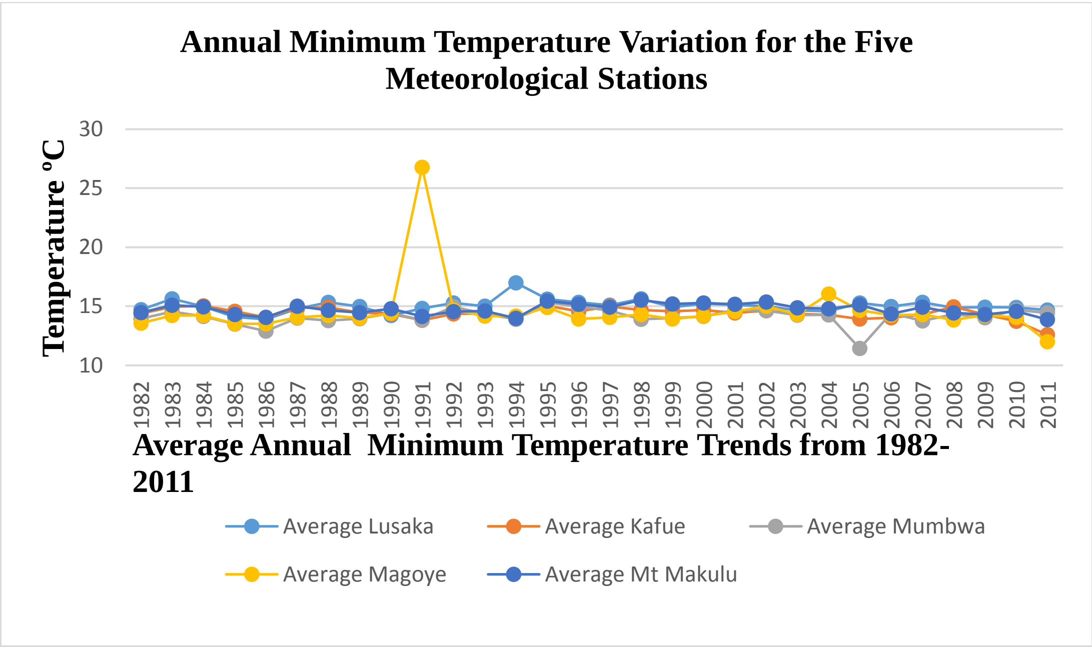

Figure 4.66 : Average Annual Minimum Temperatures.

Source: Field work data, 2014.

In general, the mean annual minimum temperatures for the Kafue Flats exhibited both increasing and decreasing trends. Nonetheless, the observed trends in mean annual minimum temperatures are not statistically significant at a = 0.10 with a z-statistic of 0.714.Thus, the average annual minimum temperatures had been changing at a rate of -0.0018 per annum (See figure 4.67 below).

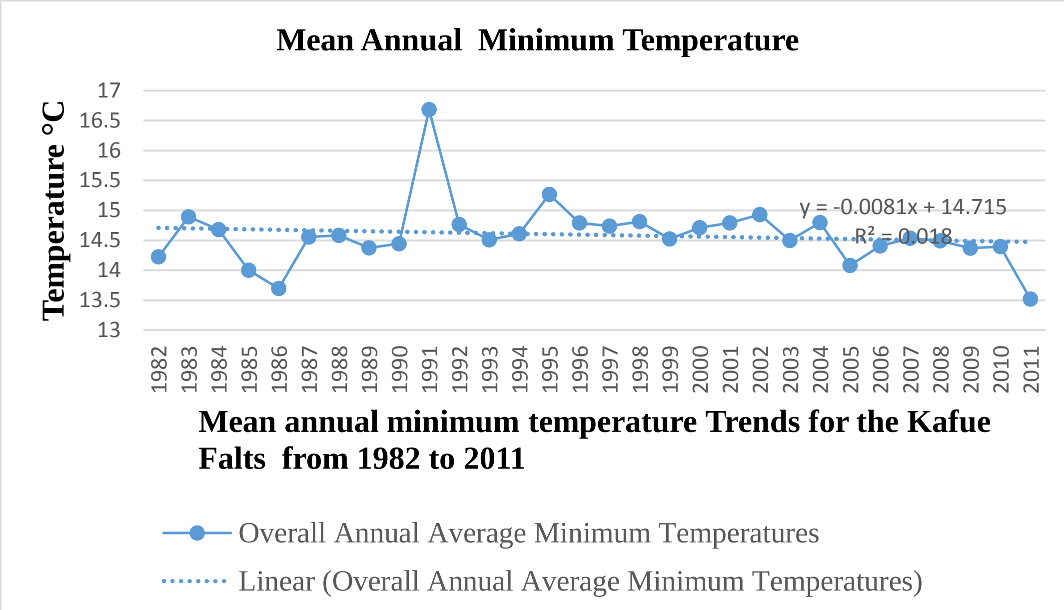

Figure 4.67 : Average Annual Minimum Temperatures for the Kafue Flats.

Source: Field work data, 2014.

Ultimately, a detailed analysis of overall mean annual temperatures for the Kafue Flats depicted both upward and downward trends. The mean annual temperatures had been changing at a rate of -0.0015ºC per annum during the 30 year period (See figure 4.68 below). Nevertheless, the observed trends in mean annual temperatures are not statistically significant at a = 0.10 with a z-statistic of -0.393. The R^2 value of -0.0015 indicates that only 0.15% of the change was observed in mean annual temperatures over the Kafue Flats from 1982 to 2011.The overall lack of change in temperature is attributed to the fact the Kafue Flats are surrounded by the Kafue River which could have had a neutralizing effect on the observed temperatures.

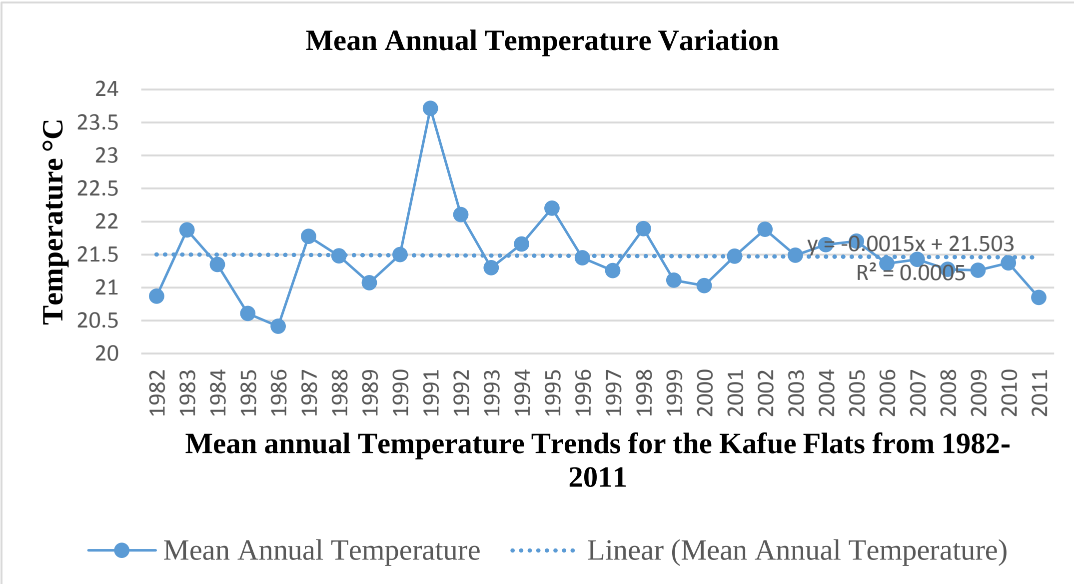

Figure 4.68 : Overall Average Annual Temperatures for the Kafue Flats.

Source: Field work data, 2014.

The next section discusses the periodic variation in the size of the Kafue Flats catchment area.

4.3 Periodic Size Variation of the Kafue Flats using Remotely Sensed Data

Coastal management and assessment of water resources have employed remotely sensed imagery for a long time. Modified Normalized Difference Water Index (MNDWI) intensifies the visibility of open water features and sufficiently suppresses and removes vegetation, built-up land and soil noise (Xu 2006). Xu (2006) indicated that delineation of open water requires use of thematic techniques in order to extract information. Consequently, Xu (2006) noted that alteration of the Normalized Difference Built-up Index (NDWI) using Middle Infrared (MIR) band in place of Near Infrared (NIR) band significantly enhances open water features. In this case, water is rapidly and precisely discriminated from non-water features (Xu 2006). Because MNDWI can considerably diminish and eliminate built-up noise, it is more appropriate than NDWI when it comes to enhancement of water that has many built-up areas in its background (Xu 2006). Holtz (2007) observed that Landsat images are freely available to the public. Thus, the satellite imagery data for this study was collected from National Remote Sensing Centre (NRSC) in Lusaka, Zambia. The satellite images are from Landsat 5 TM while the path and row are 172/071. The size of the pixel for a Landsat Multispectral imagery is 30m by 30 m (Holtz 2007). These images in Table 4.14 below were chosen to show through visual interpretation how the area varies through each season. The years chosen were approximately more than 5 years apart.

Table 4.14 : Landsat 5TM images of p172/r071 with the three seasons of the year

Season	1990	1997	2002
cool dry winter(May and August)	21-June	8-June	13-May
Hot and dry (sunny season)(August to mid-November)	27-October	11-August	17-August
Warm wet season(rainy season) (mid-November to end of April)	01-March	21-April	22-February

Source: National Remote Sensing Centre (NRSC), Lusaka, Zambia, 2014

4.3.1 Methodology

The study of Land use and Land cover change have become thought-provoking over the last few decades (Li and Yeh 2004). Erbek *et al*. (2004) noted that modifications in Land use and Land cover patterns are due to increased economic pressure and development. Thus, pattern recognition has had ongoing developments over the last three decades (Pal and Mather 2003). Remote sensing analysis utilizes information from the satellite imagery data. Erbek *et al*. (2004) stated that systematic coverage of multi-temporal satellite sensor data is the most efficient method of providing remote sensing information. The remote sensing work applied in this study (project) is Change detection. Change detection technique is a process of identifying areas which have undergone change or difference in state or phenomenon by observing them over two or more dates (Singh (1989); Berberoglu and Akin (2009). Change detection is based on the surface reflectance from the earth's surface. It does not necessarily mean that the land has changed over the period of time, other elements such as atmospheric conditions may trigger a change on the area (Erbek *et al*. 2004). For instance, some other aspects like abrupt natural disasters could lead to places changing over a specific time period (Erbek *et al.* 2004).

4.3.1.1 Band Combinations/ Colour compositions

Colour composition is used in remote sensing analysis. The aim of composite colours is to show how entities are reflected on a specific band (Chuvieco and Huete 2009). These are the most essential ingredients in remote sensing. "This process allows one to simultaneously visualize data in several spectral ranges, which can facilitate the visual discrimination of land surface features and land cover types" (Chuvieco and Huete 2009). According to Baumann (2010) , a single band shows an image in grey color. Nine satellite images were chosen for data analysis as shown in Table 4.13 above. The software that was used for color composition was the GIS software, ArcGIS 10.2. Consequently, this study used both true and false colour composities. The colour composites included the true colours also known as the natural colour band combination (Shao *et al.* 2013) comprising of Band 3(Red), Band 2 (green) and Band 1(blue). Conversely, the first false colour composite i.e. the "standard false colour band combination" included Band 4 (near-infrared), Band 3(red) and Band 2 (green) which are mostly used in vegetation analysis; where dark red indicates healthy vegetation, cyan blue indicates built- up areas, blue to brownish pixels indicate bare land and black to dark blue pixels indicate water bodies (Al Momani *et al.* 2007). Quinn (2001) stated that Band 4 (near-infrared), Band 5(mid-infrared) and Band (red) are the other false colour combination used in the water analysis. Quinn (2001) observed that this combination offers an additional definition of land to water boundaries and it also highlights details which are not easily apparent to bands 3, 2 and 1(visible bands). In this study, all of the aforementioned band combinations were used in image classification.

4.3.1.2 Extraction of the study area

Extraction of a particular study area is known as feature extraction. It is a process where the analyst identifies an area of study and "removes" the information pertaining to the study area (Campbell 1996). This is not the physical removal rather it is when there is specific spectral, temporal and statistical information that is required from the study area (Campbell 2002).The study area extracted was from Road bridge fishing village in Kafue district up to Nanga fishing village in Mazabuka district of Zambia (See figure 4.69 below).

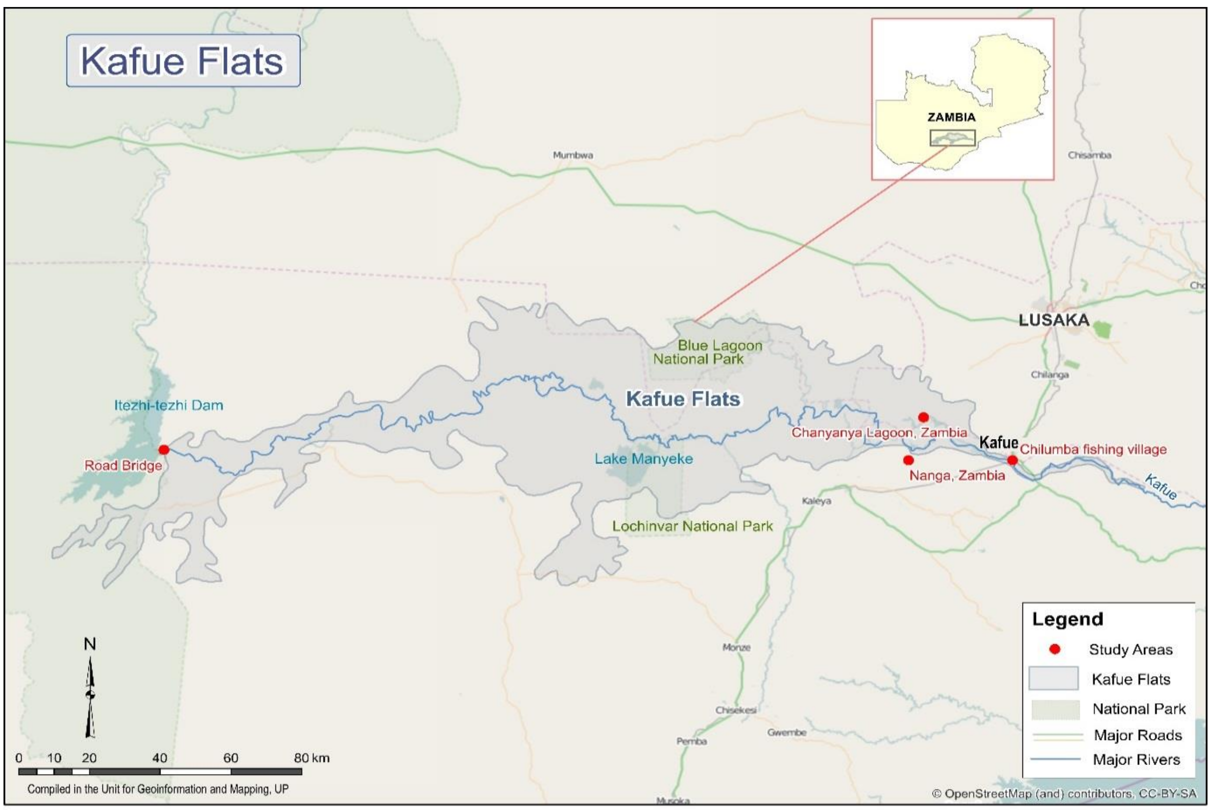

Figure 4.69 : Location of the Kafue Flats in Zambia.

Source: Generated by Ingrid Boysen, 2014.

4.3.1.3 Image Rationing

Holtz (2007) describes image rationing as dividing the value of pixels in one image to the other image. It is meant to highlight spectral differences within two images in order to produce a variable suitable for a land use class (Holtz 2007). Often times, different thematic indices are used depending on the type of land use classes one is dealing with. For instance, NDBI can be used to denote built-up land, MNDWI for open water and Soil Adjusted Vegetation Index (SAVI) can represent vegetation. However, this study utilized the Modified Normalized Difference Water Index because its main concern was to determine the periodic variation in the size of the catchment area. MNDWI often reduces and also eliminates built-up land noise especially in water regions subjected by built-up land areas in their background as was the case in this study (Xu 2006). Thus, MNDWI was appropriate in enhancement and extraction of water information (Xu 2006). According to Gao (1996); Galvão *et al.* (2005), the information pertaining to MNDWI has been a widespread utility on water stress, agriculture and hydrology throughout the entire globe.

MNDWI in this study was completed in ArcGIS 10.1 (Liu *et al.* 2012). The formula for MNDWI is provided in Equation 6 below while the MNDWI values obtained in each season for the different years are presented in Tables 4.15, 4.16 and 4.17 below.

$$MNDWI = \frac{\rho nir - \rho mir}{\rho nir + \rho mir} \qquad \text{Equation 6}$$

Where;

ρnir = Near Infrared

ρmir =Middle Infrared

Table 4.15 : 1990 MNDWI values

Season	Date	Maximum	Minimum
cool dry winter(May and August)	21-June	0.615385	-0.674797
Hot and dry (sunny season)(August to mid-November)	27-October	0.454545	-0.614213
Warm wet season(rainy season) (mid-November to end of April)	01-March	0.615385	-0.73262

Source: Field work data, 2014.

Table 4.16 : 1997 MNDWI values

Season	Date	Maximum	Minimum
cool dry winter(May and August)	8-June	0.625	-0.71223
Hot and dry (sunny season)(August to mid-November)	11-August	0.428571	-0.657143
Warm wet season(rainy season) (mid-November to end of April)	21-April	0.454545	-0.714286

Source: Field work data, 2014.

Table 4.17 : 2002 MNDWI values

Season	Date	Maximum	Minimum
cool dry winter(May and August)	13-May	0.78125	-0.66197
Hot and dry (sunny season)(August to mid-November)	17-August	0.747368	-0.629393
Warm wet season(rainy season) (mid-November to end of April)	22-February	0.77551	-0.677632

Source: Fieldwork data, 2014.

4.3.1.4 Image Classification

Image Classification entails identifying various classes on an imagery and grouping them as a specific entity (Mather and Tso 2009). In this study, image classification was performed in ENVI 5.1. The process carried out was unsupervised classification using K-means (Mather and Tso 2009). For many years, K-means have been the most widely known algorithms for unsupervised classification suitable for both segmentation and image classification (Mather 2004). Unsupervised classification means the computer selectively chooses spectral measurements of entities or classes identified and groups them altogether. This is done using a statistical algorithm that is placed on the software installed on the computer system (Mather 2004). The analyst has minimal interaction with the satellite images that are analyzed. There are two algorithms used in the unsupervised type of classification, the ISODATA and K-means classifier. Thus, this study selected the K-means classifier. According to Mather and Tso (2009) , "K-means classification or algorithm" is executed by recursively relocating a set of cluster means (centers) to mean approach through a nearby distance up until the positions of the cluster means are unchanged. This can also be achieved when modification of one iteration to the next is well below a certain predefined threshold. The number of pixels migrating from one cluster to another between iterations or a measurement value of cluster density i.e. summation of all classes based on the sum of squares of each pixel from a midpoint of its cluster defines change (Mather and Tso 2009) . The results of the classification were uploaded into ArcMap and data was converted to pixels. The pixels identified from the attribute table are presented in Table 4.18 below.

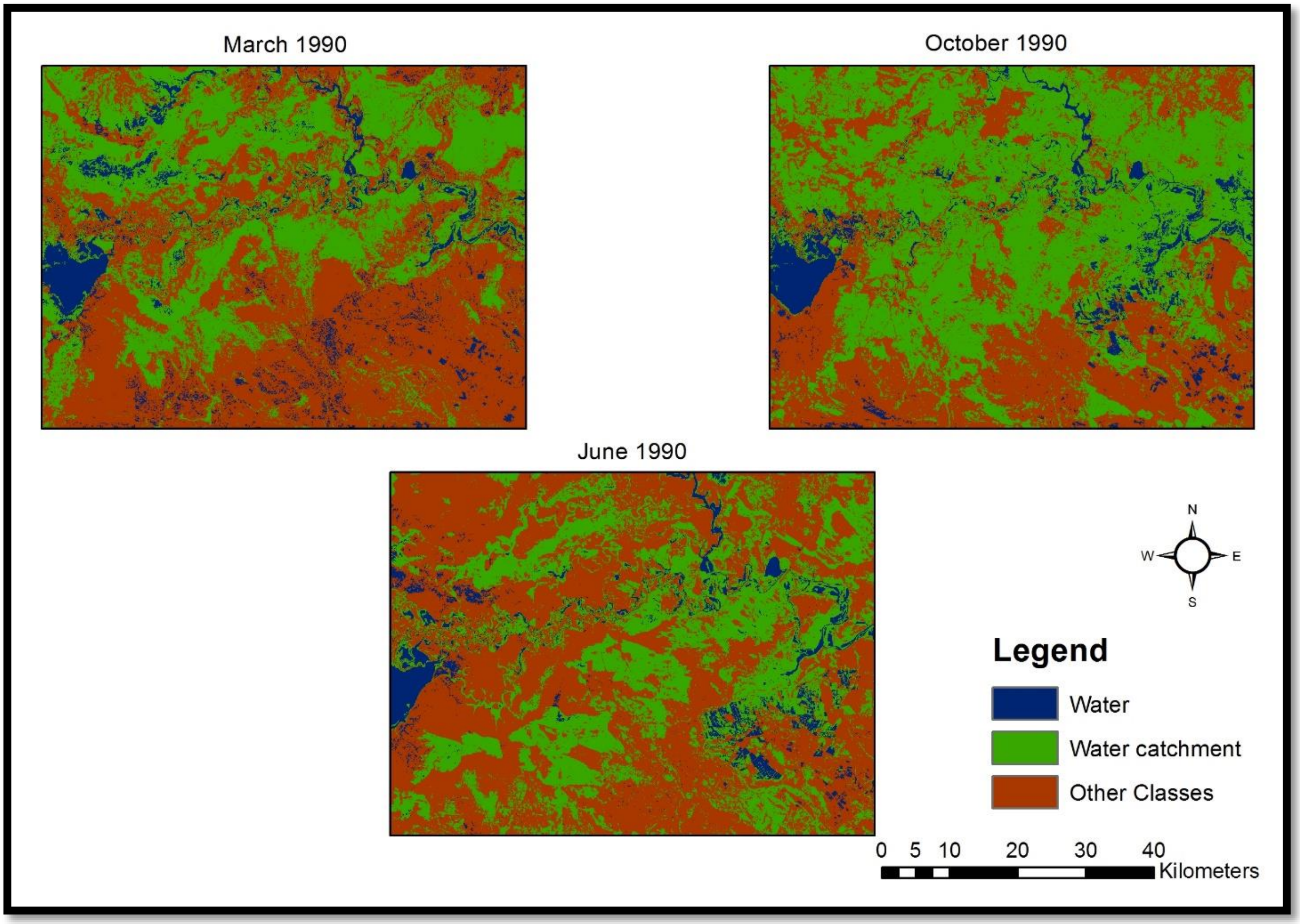

Figure 4.70 : 1990 Satellite Images.

Source: Fieldwork data, 2014.

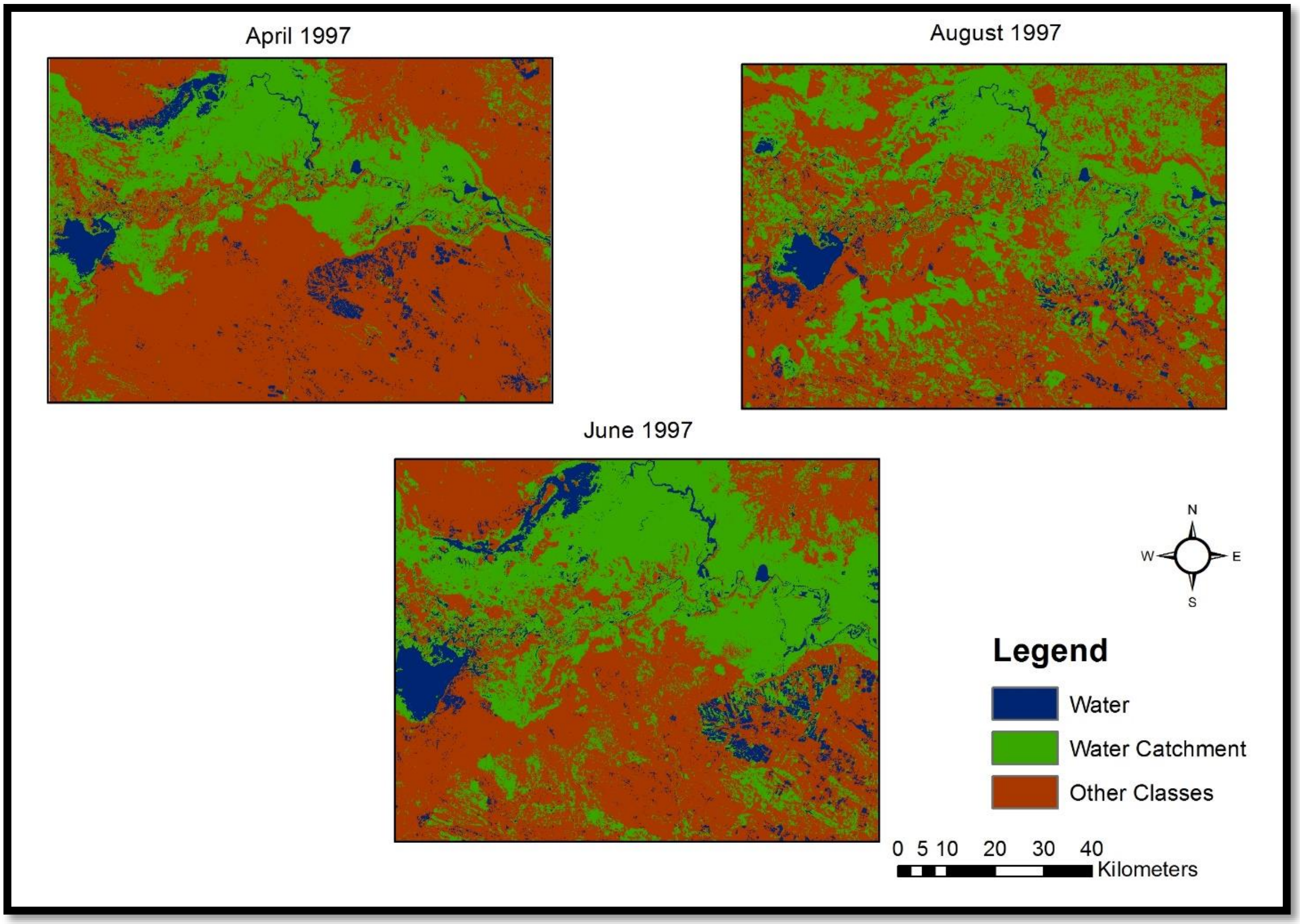

Figure 4.71 : 1997 Satellite Images.

Source: Fieldwork data, 2014.

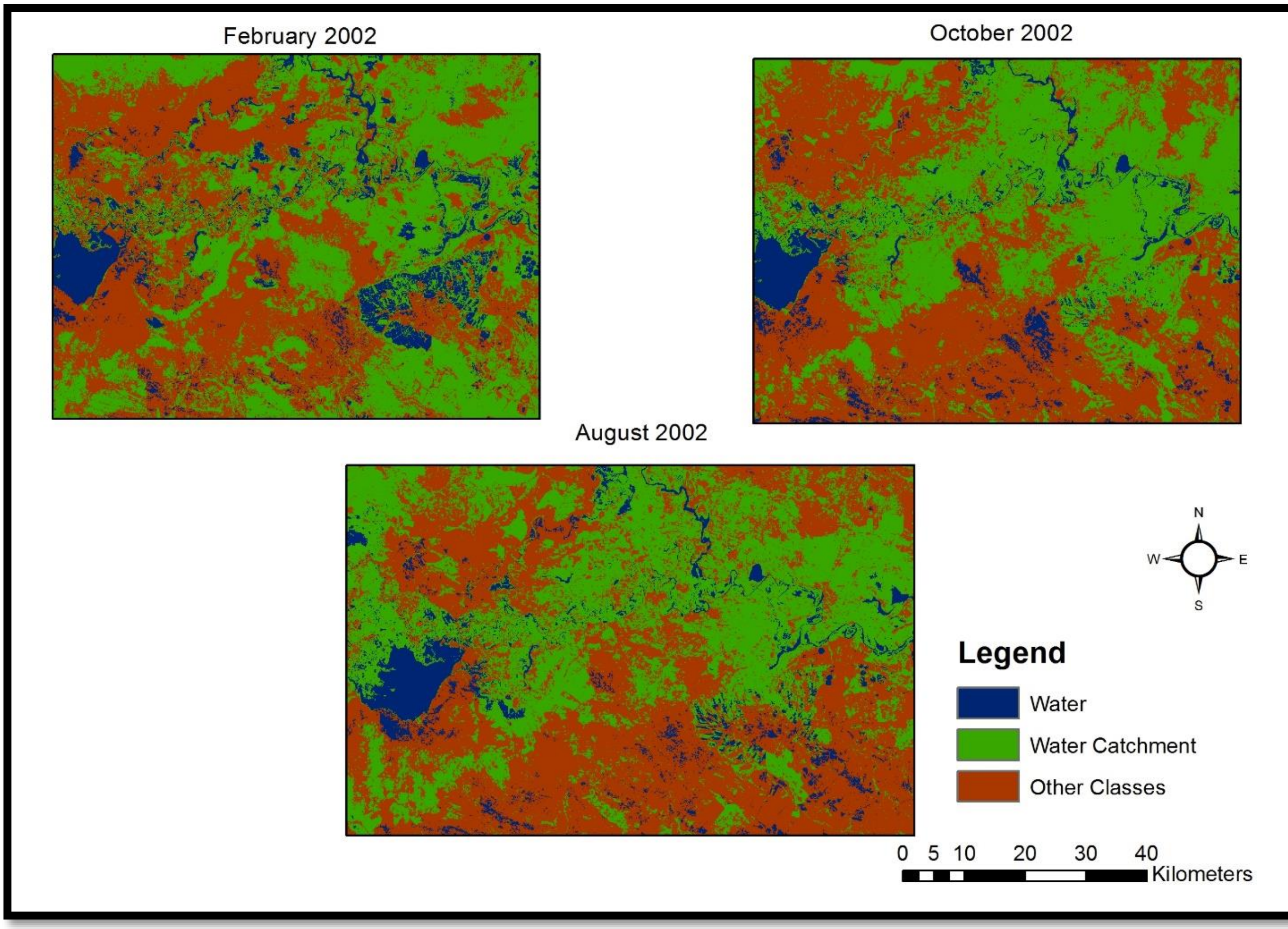

Figure 4.72 : 2002 Satellite Images.

Source: Fieldwork data, 2014.

Table 4.18 : Results of the Number of Pixels Identified using Unsupervised Classification by K-means Classifier

Year/Month/Item	Pixel count	Area M^2	Area Km^2
1990 June			
Open Water	426091	383,481,900	383.4819
Water catchment boundary	2829547	2.546.592.300	2,546.5923
Other classes	5029162	4,526,245,800	4,526.2458

1990 March			
Open Water	615065	553,558,500	553.5585
Water catchment boundary	3005539	2,704,985,100	2,704.9851
Other classes	4664196	4,197,776,400	4,197.7764
1990 October			
Open Water	564698	508,228,200	508.2282
Water catchment boundary	4120978	3,708,880,200	3,708.8802
Other classes	3599124	3,239,211,600	3,239.2116
1997 April	Pixel count	Area in m^2	Area in km^2
Open Water	510687	459,618,300	459.6183
Water catchment boundary	2346061	2,111,454,900	2,111.4549
Other classes	5428052	4,885,246,800	4,885.2468
1997 June			
Open Water	585233	526,709,700	526.7097
Water catchment boundary	3067469	2,760,722,100	2,760.7221
Other classes	4632098	4,168,888,200	4,168.8882
1997 August			
Open Water	457352	411,616,800	411.6168
Water catchment boundary	3365220	3,028,698,000	3,028.698

Other classes	4462228	4,016,005,200	4,016.0052
2002 February			
Open Water	639509	575,558,100	575.5581
Water catchment boundary	4189522	3,770,569,800	3,770.5698
Other classes	3455769	3,110,192,100	3,110.1921
2002 August			
Open Water	584104	525,693,600	525.6936
Water catchment boundary	3378067	3,040,260,300	3,040.2603
Other classes	4322629	3,890,366,100	3,890.3661
2002 October			
Open Water	568864	511,977,600	511.9776
Water catchment boundary	3595064	3,235,557,600	3,235.5576
Other classes	4120872	3,708,784,800	3,708.7848

Source: Field work data, 2014.

4.3.1.5 Change Detection Results

From the results presented in Table 4.18 above, unsupervised classification was performed and the pixel counts were obtained for all the images. The pixel counts were multiplied by the area of the pixel size of Landsat TM5 which is 30 X 30 (metres), the calculated area was then converted to square kilometres by dividing the area in metres by 1,000,000 metres. Explanations with regard to changes in the size of the catchment area for each class in different seasons are outlined in the subsequent sections.

4.3.1.5.1 Water Body in the cool dry winter season

According to the results obtained, in June 1990, the area covered by open water was 383.4819 Km with 1997 in the same season having open water with area of 459.6183 Km while 2002 the same season had area of 525.6936 Km. The aerial change shows an increase in the amount of water in the catchment area and this is so because the area had experienced floods and higher amounts of rainfall in 2002/2003 (Mubanga and Umar 2014) and this can also be seen from the rainfall data in the Excel sheet in Appendix VII.

4.3.1.5.2 Water Catchment Area in the cool dry winter season

According to the results obtained, for instance in March 1990, the area covered by water catchment area surrounding open water was 2,546.5923 Km^2 with 1997 in the same season having an area adjoining the open water with area of 2,760.7221 Km^2 while 2002 in the same season had area of 3,040.2603 Km. The increase in aerial change indicates an increase in the size of the water catchment area surrounding open water in the cool dry winter season in 1997 and 2002.

4.3.1.5.3 Other classes in the cool dry winter season

With regards to the other classes i.e. areas in proximity to the catchment area or lagoon (fishing harbour) such as vegetation, bare land, built up areas and farmland covered area of 4,526.2458 Km^2 though in 1997 the area covered by other classes was 4,168.8882 Km. However, the other classes covered a total area of 3,890.3661 Km^2 in 2002. The aerial change is decreasing, this can be attributed to the fact that often times the cool dry winter season does not receive rainfall (ADB 2013), thus the areas were decreasing in size indicating a reduction in the size of the other classes such as farm lands and built-up areas.

4.3.1.5.4 Water Body in the warm wet season (rainy season)

Rendering to the results obtained, in March 1990, the area covered by the water body was 553.5585 Km^2 whereas the water body covered an area of 459.6183 Km^2 in 1997 in the same season. However, in 2002, the water body covered a total area of 575.5581 Km^2. The aerial change indicates both decrease and increase in the size of the water body. This implies that the water body decreased in size in 1997 due to drought while the water body area expanded in 2002 due to occurrence of floods in the Kafue flats. To support this, Sichingabula (1998) observed that Zambia experienced droughts in 1997/1998 seasons. Besides, the periodic variation in the size of the water body is also visible in the satellite images presented in figures 4.70, 4.71 and 4.72 above.

4.3.1.5.5 Water Catchment Area in the warm wet season (rainy season)

With respect to the research findings, the Water Catchment Area in the rain season also had variations in terms of size. In March 1990, the area covered by water catchment area surrounding water body was 2,704.9851 Km. Meanwhile, in 1997, the water catchment area concealed an area of 2,111.4549 Km. In 2002, the area adjoining the water body was 3,770.5698 Km^2. The aerial change shows both a decrease and increase in the size of the open water area indicating that the catchment area expanded due to floods whereas the open water areas in the Kafue flats had reduced as result of a drought. Mubanga and Umar (2014) noted that Zambia had experienced above normal rainfall (floods) in the 2002/2003 seasons. The satellite images i.e. figures 4.70, 4.71 and 4.72 above clearly denote periodic size variation of the catchment area in the warm wet season.

4.3.1.5.6 Other classes in the warm wet season (rainy season)

The disparity in the area of the other classes in the dry season can be attributed to no rains or dry periods where no rainfall is received, thus less and less areas such as farm lands are cultivated. For instance, in March 1990, the areas in proximity to the catchment area or lagoon (fishing harbour) covered an area of 4,197.7764 Km^2 yet in 1997 the area covered was 4,885.2468 Km^2 conversely in 2002 the area covered was 3,110.1921Km^2. In this season, the aerial change detected reduced between 1990 and 1997 while there was an increase in 2002. In 2002, the area had received more rainfall compared to the other years in the same season (Mubanga and Umar 2014) whereas droughts occurred in the 1991/1992, 1994/1995 and 1997/1998 warm wet season (Sichingabula 1998).

4.3.1.5.7 Water Body in the hot and dry (sunny season)

With reference to the results obtained, in October 1990, the area covered by the water body was 508.2282 Km^2 in the sunny season. However, in 1997, the water body covered an area of 411.6168 Km^2. In 2002, the water body had a total area of 511.9776 Km^2. The aerial change indicates a decrease in the water body in 1997 which can be attributed to the droughts of 1997/1998 (Sichingabula 1998) while the increase in aerial change in 2002 is as a result of floods of 2002/2003 seasons (Mubanga and Umar 2014).

4.3.1.5.8 Water Catchment Area in the hot and dry (sunny season)

With respect to the research findings, the Water Catchment Area in the rain season had variations in terms of size. In March 1990, the area covered by water catchment area surrounding open water was 3,708.8802 Km^2 while for 1997 the area adjoining the open water was 411.6168 Km^2 although in the same season 2002, an area of 3,235.5576 Km^2 was covered by Water Catchment boundary.

4.3.1.5.9 Other classes in the hot and dry (sunny season)

In almost all countries in the world especially in Southern Africa where Zambia lies, the discrepancy in the area of the other classes i.e. the areas in proximity to the catchment area or lagoon (fishing harbour) such as vegetation, bare land, built up areas and farmland in the sunny season can be ascribed to the higher temperatures and no rains or dry periods where no rainfall is received and as such less and less areas such as farm lands are cultivated. For instance, in March 1990, the areas in proximity to the catchment area or lagoon (fishing harbour) covered an area of 3,239.2116 Km^2 yet in 1997 the area covered was 4,016.0052 Km^2. Conversely in 2002 the area covered was 3,708.7848 Km^2.

Overall, the satellite images considered in change detection analysis clearly indicate periodic variations in the size of the catchment area. These periodic size variations of the catchment area affect fishing activities in different seasons. For example, when the catchment area gets flooded, large amounts of fish is caught while during droughts, reduced amounts of fish are caught. In general, the catchment area expands during floods and the floods bring along a lot of nutrients for fish to feed. Henceforth, it is during this time that increased amounts of fish are caught.

The next section discusses the demographic and socio-economic characteristics of the respondents.

4.4 Demographic and Socio-economic Characteristics of the Respondents

The demographic characteristics of interest in this study included gender, age, level of education, and marital status while the socio-economic characteristics comprised of sources of income apart from fishing, monthly household income, monthly income from fishing, number of years lived in the chiefdom and the number of people living in the household. The research findings indicate that the majority of the respondents i.e. 98.2% were male as compared to 1.8 % who were female. During the survey, the men were mainly seen catching fish while women dominated fish processing and fish trading as most of them were found along the banks of the lagoons buying fish from the men coming out of the swamps. Males are dominantly employed as boat crew, fish factory agents and transporters of fish. For instance, during the survey, a number of males were buying fish from the fisher-folk and transporting it to the nearby towns.

A scrutiny by age revealed that a large number of the respondents (34.5%) were aged between 31-40 years, 23.6 % were aged between 21-30 years, 20.9% of the respondents were aged between 41-50 years 17.3 were above 50 years old while 3.6 were below 21 years of age (see Table 4.19 below). This implies that majority of the fisher-folk are in the age bracket of 21-50 years. This age group is generally the most economically productive since they have the energy to undertake tedious activities like fishing and are responsible for taking care of the young and old age groups. The age characteristic is also supported by the findings of the CSO (2006) fishery report where the demographic characteristics revealed that the age group 30 to 34 years had the highest number of active fishermen in Stratum I, II and III while Stratum IV had age group 40 to 44 years dominating. A marked variance in education status of the respondents indicated that most of the respondents (61.8%) had attained primary education, 28.2% attained secondary education and 0.9% had tertiary education meanwhile 9.1 % reportedly had no formal education. This is similar to Lwenya *et al*. (2009) findings that both men and women in most African countries such as Tanzania, Kenya and Uganda tend to be poorly-educated, mostly with a high proportion being primary school drop outs especially amongst women. Often times, lack of education limits their chances of finding alternative employment outside fishing. Consequently, the poorly educated males are more likely to be employed as mere crew members.

With reference to the marital status, the majority of the respondents i.e. 74.5% were married, 15.5% were unmarried, 6.4% were divorced whereas 2.7 % were widowed and only 0.9 % were divorced. The greater number of married respondents indicates that the majority of the men had their wives or children to carry out post-harvest activities such as fish processing whilst the men were busy fishing. With regard to household size, the vast majority (47.1%) of the respondents live with 6 – 10 people in their homes, 39.1 % live with 5 or less people in the household while 11.8% of the respondents live with more than 10 people in the same household (See Table 4.19 below). In respect of the number of years the respondents had lived in the chiefdom, the majority (77.3%) of the respondents lived in Chieftainess Nkomesha’s chiefdom for more than 10 years, 10.9% lived in the chiefdom between 4 – 6 years while 7.3% of the respondents lived in the chiefdom between 7 – 9 years with 4.5% of the respondents living in the chiefdom for

3 years or less. With reference to the sources of income apart from fishing, the majority (45.5%) of the respondents had no other sources of income besides fishing, 27.3 % of the respondents were involved in agriculture (small scale farmers), 17.3% of the respondents would do manual work to earn a living, 9.1 of the respondents were net menders while hand-outs provided an alternative source of income for 0.9 % of the respondents. Regarding the fisher-folk sources of income, 80% of the respondents earn below 2,000 Kwacha or less per month, 14.5 % earn between 2,001 and 6,000 Kwacha, 2.7 % earn between 6001 – 10,000 Kwacha with another 2.7% of the respondents earning well above 10,000 Kwacha per month. Additionally, the research findings with regard to monthly income from fishing indicate that majority (88.2 %) of the respondents earn 2000 Kwacha or less per month, 7.3 earn between 2001 and 6000 Kwacha while 3.6 % earn in the range of 6001 – 10,000 Kwacha with 0.9% of the respondents earning well above 10,000 Kwacha per month. Table 4.19 summarizes demographic and the socio-economic characteristics of the respondents.

Table 4.19 : Socio-economic and Demographic Characteristics of the Respondents.

Characteristics	Frequency	Percentage
Gender		
Male	108	98.2
Female	2	1.8
Age Group		
Less than 21 years	4	3.6
21 – 30 years	26	23.6
31 – 40 years	38	34.5
41 – 50 years	23	20.9
Above 50 years	19	17.3
Level of Education		
None	10	9.1
Primary	68	61.8
Secondary	31	28.2
Tertiary	1	0.9
Others(Specify)	0	0
Marital Status		

Unmarried	17	15.5
Married	82	74.5
Divorced	7	6.4
Widowed	3	2.7
Separated	1	0.9
Household Size		
5 persons or less	43	39.1
6 persons - 10 persons	54	49.1
More than 10 persons	13	11.8
Number of Years Lived in the Chiefdom		
3 years or less	5	4.5
4 – 6 years	12	10.9
7 – 9 years	8	7.3
10 years and above	85	77.3
Sources of Income Apart From Fishing		
Agriculture (Farmer)	30	27.3
Manual Work	19	17.3
Hand out	1	0.9
Net Mender	10	9.1
None	50	45.5
Monthly Household Income		
K 2,000 or Less	88	80.0
K 2,001 – K 6,000	16	14.5
K 6,001 – K 10,000	3	2.7
Above K 10,000	3	2.7

Source: Fieldwork data, 2014.

4.4.1 Perceptions of respondents on whether or not climate variability affects fisher-folk and fishing activities

Climatic changes may sometimes have adverse effects on the fisher-folk due to the dangers it imposes. Direct impacts of climate change generally affect fish processing and trade (Badjeck *et al*. 2010). For instance, fishers in Mississippi area of the United States were incapable of catching, selling and buying fuel or ice due to the occurrence of hurricane Katrina (Buck 2005). Similarly, rural fishing communities in Peru were unable to access their usual markets due to interruption of the road infrastructure following the occurrence of heavy rains in 1998 (Pfaff *et al.* 1999). This study endeavored to assess climate variability impacts on fishing activities and lives of the fisher-folk. The first step was to find out whether the fisher folk were aware that climate variability affects them as individuals as well as their fishing activities. Interestingly, the majority of the respondents (96.4%) as shown in figure 4.73 acknowledged that climate variability in terms of strong winds, high rainfall, storm, drought, flooding and high temperatures affects their fishing activities. Meanwhile only 3.6 % of the respondents observed that climate variability does not affect the fisher-folk and the fishing activities. FAO (2008) stated that from the 1960's onwards, many lakes have increasingly warmed up while others are receding in size and reducing in depth. Consequently, fishing activities especially in African lakes will negatively be affected because the atmospheric temperature of the African continent is projected to be greater than the global average (FAO 2008). Besides, rainfall is also predicted to decrease (FAO 2008). When asked whether changes in lake water levels affects their fishing activities, all the respondents (100 %) indicated that changes in lake water levels affects their fishing activities. To support the latter statement, Daw *et al.* (2009) observed that lake fishing especially in Africa is impacted by reduced lake levels and catches due to reduced precipitation and high run off as a result of weather and variability. Likewise, Crandall (2009) pointed out that receding water level in Lake Victoria is due to the degradation and loss of wetlands which is more rapid than that of other ecosystems

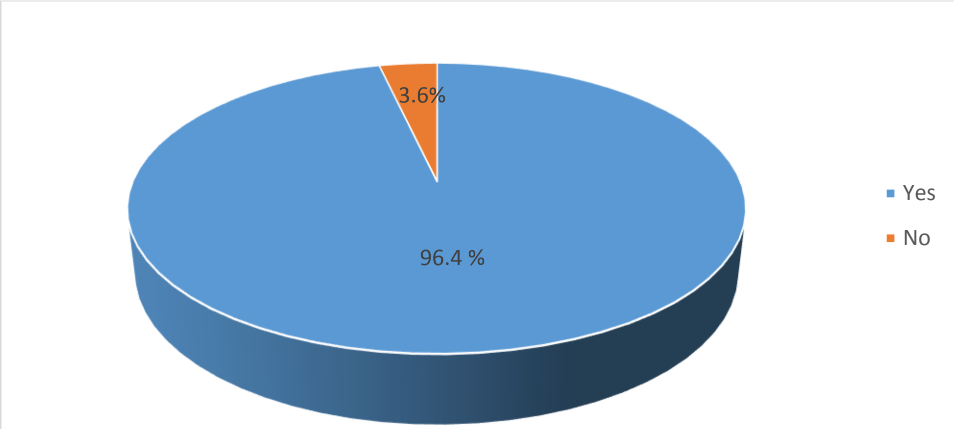

Figure 4.73 : Perceptions of the Respondents on whether or not Climate Variability affects the Fisher-folk and the Fishing Activities.

Source: Fieldwork data, 2014.

4.4.2 Effect of Different Water Levels on the Amount of Fish Catch

Generally, climate variability highly controls many fisheries through ecological impacts (FAO 2009a). Jul-Larsen (2003) stated that the climate variability predominantly drives the dynamics of fisheries in African lakes. Therefore, both the ecosystems and fishing communities that live closest to such water bodies profoundly adapt to extensive variations in lake size and depth, alterations in aquatic productivity and magnitude of flood plains (Jul-Larsen 2003). With regards to the effect of different water levels on the amount of fish catch presented in Table 4.20 below, the majority (60.9%) of the respondents pointed out that moderate water levels have high positive effects on the amount of fish catch. Thus, large amounts of fish are caught in moderate water levels. This is because during such periods, fish swims to the surface in search of food and as a result the fisher-folk catches enough fish. However, 55.5 % of the respondents stated that low water levels have high negative effects on the amount of fish catch indicating that during low water levels, small amounts of fish are caught. Similarly, 44.5% of the respondents said that high water levels have high negative effects on the amount of fish catch, thus low amounts of fish are caught. This is because the water becomes cloudy during a heavy down pour inhibiting fish sight thus the fish swims to the bottom of the lake.

Table 4.20 : Perceptions of Respondents on the Effect of Different Water Levels on the Amount of Fish Catch.

Water level	Effect									
	Very high		High		Moderate/Normal		Low		Very low	
	f	%	f	%	f	%	f	%	f	%
High water level	9	8.2	19	17.3	5	4.5	49	44.5	28	25.5
Moderate water level	4	3.6	11	10	67	60.9	25	22.7	3	2.7
Low water level	12	10.9	61	55.5	9	8.2	21	19.1	7	6.4

Source: Fieldwork data, 2014.

4.4.3 Effect of Climate Variability on the Fisher-folk and Fishing Duration

Badjeck (2008) noted that climate variability has direct impacts on the fisher-folk and thus, climate change impacts may lead to loss of life among other things. Table 4.21 below summarizes the fisher-folk's expressions with regard to impacts of climate variability on themselves. These impacts are discussed in the subsequent sub-sections.

Table 4.21 : Effect of Climate Variability on the Fisher-folk.

Variability	Loss of life due to boat capsizing		Sickness of Fisher-folk due to injuries		Loss of fishing gear in water		No effect		No response	
	f	%	f	%	F	%	f	%	f	%
High rainfall	30	27.3	2	1.8	39	35.5	37	33.6	2	1.8
Moderate rainfall	0	0	0	0	10	9.1	98	89.1	2	1.8
Low rainfall	2	1.8	0	0	0	0	106	96.4	2	1.8
High temperature	0	0	0	0	2	1.8	106	96.4	2	1.8
Moderate temperature	0	0	0	0	0	0	108	98.2	2	1.8
Low temperature	0	0	0	0	0	0	108	98.2	2	1.8
Strong winds	1	0.9	0	0	73	66.4	12	10.9	24	21.8
Storm	100	90.9	0	0	0	0	7	6.4	3	2.7

Calm condition	0	0	0	0	2	1.8	105	95.5	3	2.7
Flood	3	2.7	0	0	11	10	93	84.5	3	2.7
Drought	0	0	0	0	11	10	95	86.4	4	3.6

Source: Fieldwork data, 2014.

4.4.4 Effect of Changes in Wind Patterns on the Fisher-folk

From Table 4.21 above, the majority of respondents i.e. 90.9 % and 66.4 % indicated that storms and strong winds have adverse effects on the fisher-folk respectively. Notably, the respondents pointed out that the fisher-folk may lose their lives and also their fishing gears due to boat submergence during heavy storms and strong winds. Similarly, the respondents further indicated that heavy stormy rains have the larger potential to wreak havoc and death. However, 6.4 % and 10.9 of the respondents said that storms and strong winds had no effect on them respectively. The above findings correspond with Crandall (2009) observations that changes in wind patterns and occurrence of severe storms as a result of climate variability are likely to impact on fish production, species composition, distribution, safety and efficiency of fishing. Correspondingly, Badjeck *et al.* (2010) noted that productive assets and infrastructure such as land sites, boats and other fishing gears are likely to be destroyed by heavy storms and extreme weather events, thereby negatively impacting on the health of the fisher-folk. Nevertheless, 96.4% of the respondents preferred high temperatures while 98.2% of the respondents preferred both moderate and low temperatures as well as calm conditions (95.5%) as ideal environments for their fishing activities. The fisher-folk said that during these seasons, they are able to fish in a calm manner and thus catch large amounts of fish without any disturbances caused by the changes in the climate.

4.4.5 Effect of Changes in Rainfall Patterns on the Fisher-folk

The research findings in Table 4.21 show that changes in rainfall patterns affect the fisher-folk in the Kafue Flats. For instance, 35.5 % of the respondents noted that high rainfall or heavy down pour results into loss of their fishing gear in the water while 27.3% said that high rainfall leads to loss of lives resulting from submergence of the fishing vessels. Meanwhile, 1.8 % of the respondents pointed out that some fisher-folk fall sick due to body injuries acquired when their vessels are swept during high rainfall. With regard to moderate and low rainfall, an overwhelming majority (89.1% and 96.4% respectively) of the fisher folk indicated that moderate and low rainfall have no effect on the lives of the fisher-folk. Drought, being another aspect of rainfall seemed to have little effects on the fisher-folk because 86.4 % of the respondents pointed out that drought has no effect on them. Similarly, 84.5% of the respondents noted that floods have no effect on the fisher-folk although 2.7% of the fisher-folk pointed out that flooding results in the loss of lives when fishing vessels capsize. During the survey, officials from the Fisheries Department in Kafue indicated that the amount of rainfall certainly influences the number of fisher-folk engaging in fishing activities whereby during high rainfall many people tend to go fishing due to increased fish in the swamps while during low rainfall and drought, few people go fishing due to low yield. Therefore, a greater number of fisher-folk are at risk given the above stated consequences of high rainfall, storms and strong winds.

4.4.6 Effect of Changes in Temperature Patterns on the Fisher-folk

Based on the research findings displayed in Table 4.21 above, temperature variations have little or no effect on the fisher-folk. Majority of the fisher folk indicated that high temperatures (96.4%), moderate temperature (98.2%) and low temperature (98.2%) had no effect on the fisher-folk. In general, the fisher-folk tend not to go fishing during high temperatures because of low fish yield. This concurs with FAO (2008) remarks that increase in atmospheric temperature can lead to fluctuations in the distribution and abundance of fish species in the lakes and swamps. FAO (2008) further added that changes in temperature are expected to positively and negatively impact cold and warm water species respectively. This implies that temperature directly influences the number of fisher-folk going to fish in the swamps and lakes.

4.5 Effect of Climate Variability on fishing duration

The study sought to establish whether changes in wind, rainfall and temperature patterns affect duration of fishing. This is because weather and climate variability can impact fishing duration in multiple ways. The research findings are summarized and presented in Table 4.22 below.

Table 4.22 : Effect of Climate Variability on Fishing Duration.

Variability	Time period							
	Long time period		Normal time period		Short time period		No fishing at all	
	f	%	f	%	F	%	f	%
High rainfall	8	7.3	7	6.4	22	20	73	66.4
Moderate rainfall	3	2.7	34	30.9	60	54.5	13	11.8
Low rainfall	2	1.8	53	48.2	43	39.1	12	10.9
High temperature	5	4.5	94	85.5	10	9.1	1	0.9
Moderate temperature	1	0.9	104	94.5	5	4.5	0	0
Low temperature	4	3.6	54	49.1	44	40	8	7.3
Strong winds	0	0	2	1.8	8	7.3	100	90.9
Storm	0	0	0	0	7	6.4	103	93.9
Calm condition	7	6.4	92	83.6	7	6.4	4	3.6
Flood	12	10.9	62	56.4	36	32.7	0	0
Drought	28	25.5	34	30.9	45	40.9	3	2.7

Source: Fieldwork data, 2014

4.5.1 Effect of Changes in Wind Patterns on Fishing Duration

Fish duration in this study was explained based on the amount of time a fisher-folk spends trying to catch fish regardless of climatic effects. Hence, the fisher-folk indicated different time periods they spent fishing and the research asked them as to whether the changes in climatic conditions affected their fishing duration, the exact time a fisher-folk spent (his/her entire fishing time) without any disturbance was considered normal time. If the climatic conditions change, the fisher-folk was assumed to either spent little or more time on fishing depending on the climatic conditions at that particular time thus bringing in the various time slots such Long time period and Short time period. However, sometimes the fisher-folk would not fish at all because of the prevailing climatic conditions at a particular time period. From the research findings in Table 4.22 above, the majority (90.9 %) of the respondents stated that there is no fishing at all during strong winds, 7.3 % said they take shorter time periods fishing during strong winds for fear of drowning especially when there are heavy rains associated with strong winds. However, only 1.8% of the respondents indicated that they are able to fish in their normal time periods during strong winds. Calm conditions provide the fisher-folk with favorable conditions to venture into the waters for a longer period of time without the fear of submergence or losing their fishing gears. When asked about the fishing duration during calm conditions, 83.6% of respondents indicated that they often fish at their normal time periods. Moreover, 6.4% of the respondents spend longer time periods fishing while another 6.4% of the respondents taking a shorter time fishing. Nevertheless, only 3.6 % of the respondents indicated that they do not fish at all during calm conditions.

During stormy conditions, 93.9% of the fisher-folk indicated that there is no fishing at all while only 6.4% of the respondents pointed out that they spend very little time fishing in stormy conditions. The fear of strong winds and storms keeps away the fisher-folk thus either shortening the fishing duration or leading to no fishing at all. In support of the aforementioned research findings, Johnson (2012) stated that increased frequency and severity of storms or climate variability may be unsuitable for fishing. Likewise, Fedoulov *et al*. (1996) noted that strong winds drive the water currents very fast thus affecting fish catch. In addition, Awange and Ong’ang’a (2006) also indicated that wind speed and intensity in Bukoba (Tanzania) and Musoma influenced the amount of fish catch per vessel either positively or negatively. These observations are therefore in agreement with the findings of this study.

4.5.2 Effect of Changes in Rainfall Patterns on Fishing Duration

Changes in rainfall patterns often have different impacts on the duration of fishing in that they may either prolong or shorten the fishing duration. The research findings in Table 4.22 above show that rainfall patterns affect the fishing duration of the fisher-folk in the Kafue Flats. Hence, the amount of time spent on fishing by the fisher-folk is either reduced or increased. During high rainfall; 64.4% of the respondents indicated that there is no fishing at all, 20 % of the respondents spend shorter time periods fishing, and 7.3% spend longer time periods while only 6.4 % of the respondents stated that they fish at their normal time periods during high rainfall seasons. With regards to moderate rainfall, 54.5% of the respondents pointed out that they spend short time periods while during low rainfall, a greater number (48.2%) of the respondents indicated that they spend their normal time fishing. During droughts, the research findings indicate that the fishing duration often range from shorter time periods (40.9%) to normal time periods (30.9%) and finally to longer time periods (25.5%). However, 2.7% of the respondents stated that there is no fishing at all. In support of the above statements, Daw *et al*. (2009) observed that during droughts, the fishers around Lake Chilwa in Malawi opt for other sources of livelihood due to reduction in fish yields.

Conversely, flooding had a positive impact on the fishing duration. During floods, the 56.4% of the respondents spend their normal time fishing because floods bring along a lot of nutrients for fish and it is during this time that increased amounts of fish are caught. Although floods threaten safety of the fisher-folk in the water, 32.7% of the respondents indicated that high yields can be harvested over a short time period. In agreement with the above research findings, Allison *et al.* (2005) noted that flooding raises fish yields mainly as a result of increased basin run off and discharge rates. In Lake Victoria, most fish species do have breeding and spawning season in different times, but with a peak at the end of rainy season. Similarly, Lowe-McConnell (1987) stated that during rainy seasons, nutrients are injected into the lake from the land and this leads to phytoplankton bloom. Moreover, Owiti (1986) observed that heavy rains also play a vital role in the breeding activities as some fish species of Lake Victoria fluctuates in abundance during drought and flood years.

4.5.3 Effect of Changes in Temperature Patterns on the Fishing Duration

Respondents were asked to indicate whether changes in temperature patterns affect their fishing duration. During high temperature and moderate temperature seasons as shown in Table 4.22, the majority of the respondents (85.5% and 94.5% respectively) spend their normal time period fishing. However, 49.1% of the fisher-folk indicated that they spend normal time periods fishing during low temperatures. On the contrary, during the survey, most of the fisher-folk indicated that low temperatures negatively affect their fishing duration. They spend more time on the lake trying to catch because fish tends to hide underneath during winter (cold temperatures). Hence, this makes it difficult for them to catch enough fish. Some of the fisher-folk also noted fish also hides beneath the water weeds (locally known as mauzu) in the cold season making it more difficult for the fisher-folk to catch large amounts of fish. Regarding high temperatures, the fisher-folk tend not to go fishing because of low fish yield. In support of the above statements, O'Reilly *et al*. (2003) noted that fish production in Lake Tanganyika had declined in the recent past largely due to increasing temperature. IPCC (2007b) also supports this view that there is one school of thought that holds that biological productivity of some fish species may escalate with increasing temperature just to ascertain threshold, but in some species, the decline in productivity comes with the increase in temperature. This certainly supports the view that temperature influences fishing duration.

4.6 Types of Fish Caught in the Kafue Flats

During the survey, each respondent was asked to state the types of fish caught in the Kafue Flats. The main types of fish caught include Mpende, Milamba, Mintesa, Kababa, Shilutungu, Michena, Nkolokolo, Mpumbu and Bottle fish as shown in Table 4.23 below. The majority of the respondents i.e. 97.3% and 92.7% indicated that the largest amounts of fish caught in the Kafue Flats are "*Tilapia rendalli*" locally known as Mpende and "*Bubble fish*" locally called Milamba respectively. Conversely, fish caught in moderate amounts include Mintesa (85.5%) , Kababa (88.2%), Shilutungu (80.9%), Michena (82.7%) , Nkolokolo (73.6%).Notably, Mpumbu (47.3%) and Bottle fish (57.3%) are usually caught in little or low amounts as indicated by the fisher-folk' responses. During the survey, the respondents mentioned other types of fish tsuch as Nchenga "*Barbus unittaeniatus*" and Imbumbu "*Mormryus longiritis*". Nonetheless, these fish species rarely caught.

Table 4.23 : Types of Fish Caught in the Kafue Flats.

Types of Fish	Number of Respondents			
	Yes		No	
	f	%	F	%
Kapenta (" *Limnothrissa miodon*")	4	3.6	106	96.4
Mpende ("*Tilapia rendalli* ")	107	97.3	3	2.7
Milamba (Bubble fish)	102	92.7	8	7.3
Mintesa ("*Marcusenius macrolepidotus*")	94	85.5	16	14.5
Kababa ("*Tilapia sparmanii* ")	97	88.2	13	11.8
Shilutungu ("*Schilbe intermedius*")	89	80.9	21	19.1
Michena ("*Hepsetus odoe*")	91	82.7	19	17.3
Nkolokolo ("*Synondotis kafuensis*")	81	73.6	29	26.4
Mpumbu ("*Labeo altivelis*")	52	47.3	58	52.7
Bottle fish	63	57.3	47	42.7

Source: Fieldwork data, 2014.

4.7 Effects of Seasonal Variability on the Amount of Fish Catch

Trotman *et al.* (2009) stated that changes in fishing activities due to climate variability usually lead to fluctuations in fish catch. For instance, similar seasons may experience variable climates in different years with equivalent consequences for specific fish-stocks sizes (Trotman *et al.* 2009). Most of the fisher-folk are already familiar and often put up with such changes, and may not experience severe economic hardships more especially if their main fisheries resources are not over-harvested (Trotman *et al*. 2009). However, in the long run, climate variability may lead to corresponding changes in lake ecological conditions which may result in long-term changes in the availability of certain fish stocks (Trotman *et al*. 2009). Thus, the fish species that may have long disappeared could suddenly become more and more abundant. Trotman *et al*. (2009) indicated that the fisher-folk are likely to benefit more especially if the recently abundant fish species are of high commercial value. Conversely, the fisher-folk could be affected if at all the recently abundant fish species are endangered, presumably the endangered species could displace and also prey upon the local indigenous fish stocks (Trotman *et al*. 2009). Perhaps, changing ecology as result of climate variability may cause long-abundant and important fish stocks to become extinct (Trotman *et al*. 2009). But more often than not, joint effects of lake-ecological changes and over- fishing lead to drastic changes in the availability of fish stocks (Trotman *et al*. 2009).

Figure 4.74 below presents the annual fish production trends for the Kafue floodplain fishery over the last four decades. The amount of fish catch has been fluctuating in the Kafue floodplain fishery as shown in figure 4.74. For instance, increases and decreases in the amount of fish catch were observed over the years between 1974 and 1982. However, some years between 1974 and 1982 depicted a reduction in the amount of fish catch thus the negative relationship that is shown by the blue linear trend line in figure 4.74 below. Similarly, the orange linear trend line also indicates a decline in the annual fish production between 1983 and 1988. Nevertheless, there was an increase in fish catch from 1988 up until 1992 although the rest of the years indicate fluctuations in annual fish production. Overall, the blue and orange trend lines in figure 4.74 depict a negative relationship implying that annual fish production has been declining in the Kafue Flood Plain Fishery more especially in 1980's. The CSO (2006) fishery report indicated that the "normal reaction" to fish catch decline among fishermen in Zambia (and the world at large) is the increasing number of fishing gears, introduction of more efficient fishing techniques and even use nets of smaller mesh sizes to capture non-traditional fish species.

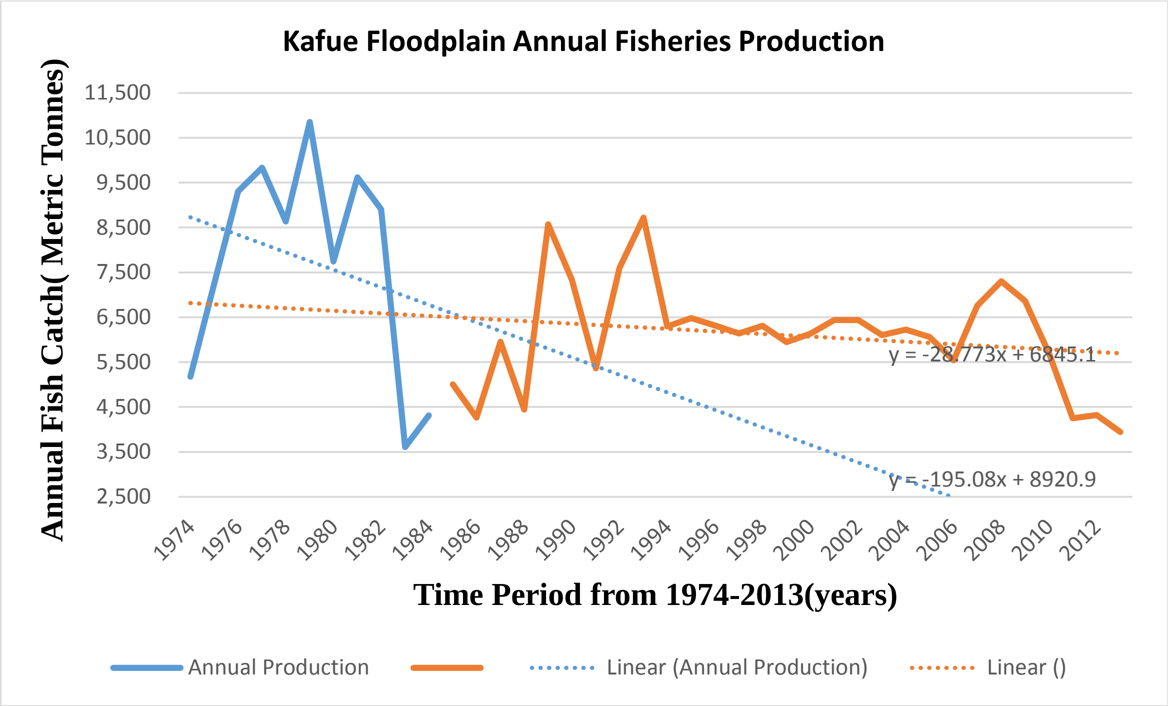

Figure 4.74 : Annual Fisheries Production for the Kafue Floodplain Fishery from 1974-2013.

Source: Chilanga Fisheries Headquarters, 2014.

With regards to the effect of climate variability on the amount of fish, the respondents were asked as to whether or not the amount of fish remains constant irrespective of climate variation, the majority (82.7 %) of the respondents said no while only 17.3 % said yes as shown in figure 4.75 below. This indicates that the amount of fish reduces or increases depending on the type of climatic event experienced at different time periods in the different parts of the Kafue Flats.

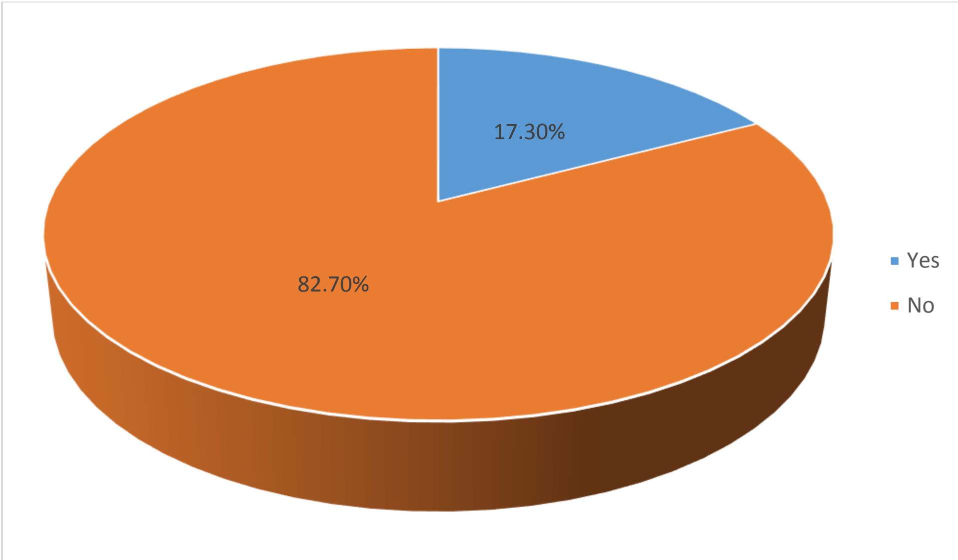

Figure 4.75 : Perceptions of Respondents on Whether or not Climate variability affects the Amount of Fish Catch.

Source: Fieldwork data, 2014.

Table 4.24 : Impact of Climate Variability on the amount of fish catch.

Variability	**Impact**											
	Very high		High		Moderate/ Normal		Low		Very low		No impact	
	f	%	f	%	f	%	f	%	F	%	f	%
High rainfall	35	31.8	25	22.7	11	10	18	16.4	5	4.5	14	12.7
Moderate rainfall	3	2.7	16	14.5	47	42.7	19	17.3	8	7.3	15	13.6
Low rainfall	5	4.5	22	20	27	24.5	33	30	7	6.4	14	12.7
High temperature	9	8.2	11	10	7	6.4	22	20	11	10	49	44.5
Moderate temperature	2	1.8	5	4.5	22	20	22	20	13	11.8	44	40
Low temperature	16	14.5	27	24.5	21	19.1	22	20	9	8.2	14	12.7
Strong winds	44	40	24	21.8	0	0	7	6.4	0	0	34	30.9
Storm	45	40.9	23	20.9	0	0	6	5.5	0	0	34	30.9

Calm condition	2	1.8	0	0	16	14.5	12	10.9	11	10	68	61.8
Flood	16	14.5	10	9.1	34	30.9	35	31.8	7	6.4	6	5.5
Drought	23	20.9	27	24.5	26	23.6	21	19.1	6	5.5	5	4.5

Source: Fieldwork data, 2014

4.7.1 Impact of Changes in Wind Patterns on the Amount of Fish Catch

Variability in wind patterns frequently affects fish catch in lakes and swamps. From the research findings in Table 4.24 above, a large number of the respondents (61.8 %) indicated that strong winds often lead to reduced fish catch. This is in line with earlier observations that fishing duration is often shortened and/or there is no fishing at all during strong winds. At the same time, the fishing vessels and gear may be destroyed during strong winds thus leading to low fish catches. At times, some fish species migrate further into the deep waters thus affecting the amount of fish catch. However, the situation is quiet different during calm conditions as 61.8% of the fisher-folk indicated that there is usually an increase in the amount of fish catch, 14.5% reported normal fish catch, 20.9% of the respondents pointed out that calm conditions have low or less impacts on the amount of fish catch while only 1.8% of the respondents noted that calm conditions have a high impact on the fish catch and as such low amounts of fish is caught. Regarding the impact of storms, the adverse impact on fish catch was as much as that of strong winds, 61.8 % of the respondents reported reduction in fish catch and only 5.5 % reported an increase in fish catch. According to Trotman *et al.* (2009), extreme climatic events such as tropical cyclones can be very damaging to the fisheries industries as they regularly lead to destruction of the fishing gear, fishing vessels and coral reefs. This often is a major setback to the fishing community due to reduced fish catch and by extension the general population (Trotman *et al.* 2009). For instance, in Jamaica and Florida, Hurricane Gilbert and Andrew in 1989 destroyed large expanse of fish habitat (mangrove) causing loss of valuable fish stock and fish species. From the secondary data obtained from Fisheries Headquarters and Zambia Meteorological Department in Lusaka, the amount of fish catch tends to increase when the winds stabilize and reduces during strong winds. This is in line with the general feeling of the fisher-folk in the region.

4.7.2 Impact of Changes in Rainfall Patterns on the Amount of Fish Catch

Often if not at all times, it is expected that rainfall would influence the amount of fish catch at any given time. Changes in precipitation and run-off resulting from climate change severely impact on the ecology of Inland fisheries (FAO 2009a). For instance, (FAO 2009a) reduced lake water levels and fish catches have profoundly affected Lake Fisheries in Southern Africa. The research findings in Table 4.24 above show a diverse impact of high rainfall on the amount of fish catch, i.e. 54.5 % of the respondents reported very high to high impact of high rainfall on the amount of fish catch, indicating low to very low catches during the high rainfall season while only 30.9 % of the respondents reported moderate to low fish catches. This may be explained by the fact that despite an increase in fish yield during high rainfall, most of the fisher-folk are deterred from venturing into the waters for a longer period of time due to the dangers posed by high rainfall. Further, the fisher-folk that take the risks record higher yields while those who stay away or venture into the waters for a short time period as result of fear, injuries or loss of vessels during high rainfall record low to very low fish catches. However, during moderate and low rainfall seasons, the fish catch is primarily moderate/normal to high (60% and 54.5% respectively). The impact of drought on the amount of fish catch was also considered and 62.7 % of the respondents stated that the amount of fish catch fluctuates from moderate/normal to very high. Thus, floods were found to positively affect the amount of fish catch in the Kafue Flats. In support of the later statement, Allison (2005) observed that a 20-40% increase in flooded areas in Bangladesh resulting from increased basin run off and discharge rates raised up the total annual fish yields between 60,000 and 130, 000 tonnes.

4.7.3 Impact of Changes in Temperature Patterns on the Amount of Fish Catch

Even though very extreme temperatures (i.e. very high and very low) have an adverse effect on fish yields, moderate to low temperatures do not have much impacts on fish yields. Based on the research findings presented in Table 4.24 above, the majority of the respondents i.e. 44.5% and 40% indicated that usually normal amounts of fish are caught during high and moderate temperatures respectively. However, during low temperatures, 58.1% of the respondents reported that the amount of fish catch ranges from moderate to very low. This corresponds with the earlier assertion made in this presentation that generally during low temperatures, the fisher-folk tend to spend long periods of time trying to catch fish because of low fish yield resulting from the fish hiding in the deep waters looking for warmth. In support of this, Mahon (2002) noted that in the Caribbean Sea, Meso scale climate variability such as the sea surface temperature changes influenced the migration and stock patterns of fish, consequently affecting the availability of fish stocks and local fishing fleets. Similarly, Johnson (2012) observed that increased stream temperature as a result of high temperatures and lower water levels in fresh water systems can reduce the productivity of spawning and rearing waters

4.8 Impact of Climate Variability on Gear/ Equipment and Techniques

Fishing equipment and techniques increase or reduce the yield of fish catch. However, choices of fishing equipment and techniques are influenced by the prevailing weather conditions. According to CSO (2006), the most commonly used fishing equipment/gear in the Kafue floodplain fishery are the gill nets (in terms of numbers). However, the Kafue floodplain fishery has other fishing gears in use namely: Seine nets, Long-line (hooks) and Baskets (CSO 2006). The use some of the gears such as seine nets is sometimes limited due to water level fluctuations which submerge or keep too low seining beeches or trap/basket setting sites. Long-line is normally species specific and may not be used successfully all year round (CSO 2006). When asked whether the fisher-folk use the same type of gear irrespective of the change in climatic conditions, 99.1% of the respondents said yes and this is so because they could not afford to use different fishing gears as most of them do not earn enough income from fishing and as such they are not able to buy the different types of gear. Henceforth, they use the same type of gear throughout their fishing seasons. On the other hand, 0.9% of the fisher-folk were not sure of whether they use the same fishing gear or not. Figure 4.76 below shows the number of respondents who said yes and those who were not sure.

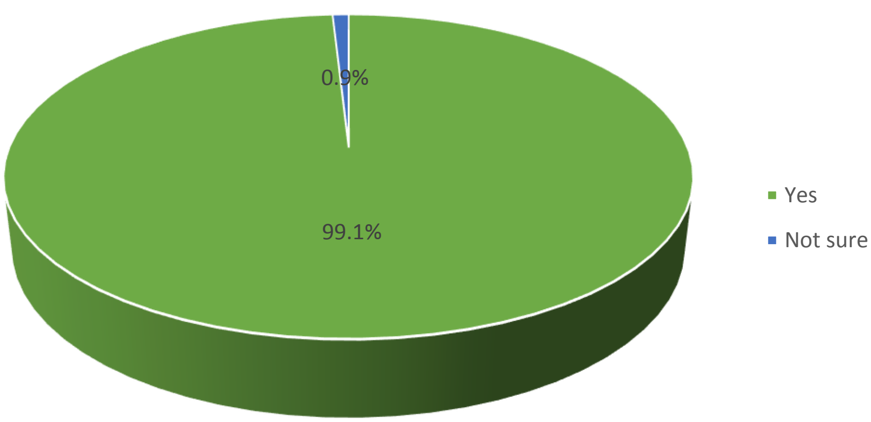

Figure 4.76 : Perceptions of Respondents on Whether or not climate variability affects their choice fishing gear.

Source: Fieldwork data, 2014.

4.8.1 Impact of Climate Variability on the Fishing Gear/Equipment

As earlier alluded to, the amount of fish catch often depends on the type of fishing gear or equipment used. Thus, fishing gear/equipment either increase or reduce fish yield. During the survey, the researcher set out to investigate the impact of climate variability (rainfall, wind and temperature) on fishing gear/equipment. The research findings are presented in the section below.

Table 4.25 : Types of gear used for fishing in the Kafue Flats

Type of gear/equipment	**Fisher-folk Response**			
	Yes		No	
	f	%	F	%
Boats	95	86.4	15	13.6
Hooks	9	8.2	101	91.8
Seine nets	17	15.5	93	84.5
Gill nets	86	78.2	24	21.8

Source: Fieldwork data, 2014

The research findings presented in Table 4.25 indicate that boats (canoes) and gill nets (locally known as malalika) are the mostly used fishing gears by the majority of the fisher-folk i.e. 86.4 % and 78.2% respectively. On the other hand, 15.5% of the respondents stated that they use seine nets (prohibited by law) while only 8.2% of the respondents said that they use hooks. During the survey, a large number of the fisher-folk were in possession of the seine nets (locally known as chikukula) but when interviewed they said they used gill nets for fear of being prosecuted as they thought the researcher was from the Department of Fisheries. Other the types of boats used as mentioned by the respondents include the banana boat and Kembe. In support of the aforementioned findings, the CSO (2006) fishery report indicated that canoes are the most used fishing gear in the entire Kafue floodplain fishery (83.83 %) followed by fibre glass boats (9.56 %). Furthermore, CSO (2006) fishery report indicated that asbestos boats still play a vital role in this fishery i.e. in Stratum I and II because this is the area where these boats were first introduced and remains proximal to Kafue town where experts to assist in mending can be found readily. Unfortunately, CSO (2006) fishery report indicated that very few fishermen still remain with the maintenance know-how. Moreover, plank boats are more important in Stratum II, because of a

Boat building shop that opened in Shimungalu Fishing village (CSO 2006). However, metal boats are not common in all the fishing villages (CSO 2006)

Table 4.26 : Impact of Climate Variability on the Fishing Gear/Equipment.

Variability	Effect					
	Capsized		Damaged		No effect	
	f	%	f	%	F	%
High rainfall	32	29.1	34	30.9	43	39.1
Moderate rainfall	1	0.9	6	5.5	102	92.7
Low rainfall	1	0.9	0	0	108	98.2
High temperature	7	6.4	0	0	101	91.8
Moderate temperature	0	0	1	0.9	108	98.2
Low temperature	0	0	0	0	109	99.1
Strong winds	88	80	3	2.7	17	15.5
Storm	2	1.8	67	62.7	12	10.9
Calm condition	0	0	0	0	108	98.2
Flood	2	1.8	8	7.3	99	90
Drought	0	0	25	22.7	84	76.4

Source: Fieldwork data, 2014

4.8.1.1 Effect of Changes in Rainfall Patterns on Fishing Gear/Equipment

From the research findings in Table 4.26 above, 29.1 % and 30.9% of the respondents indicated that fishing equipments are usually submerged and damaged during high rainfall respectively. Nonetheless, 39.1% of the respondents reported that high rainfall has no effect on fishing equipment. During moderate and low rainfall, the majority of the respondents stated that there is no effect on fishing equipment (92.7% and 98.2% respectively). High rainfall and resultant flooding is sometimes accompanied by storms that are likely to cause fishing equipments to capsize or get destroyed. However, despite the risk of submergence and destruction of fishing crafts/gear during high rainfall, most of the fisher-folk are known to venture into the swamps/lakes because fish yields are normally high during high rainfall seasons.

4.8.1.2 Effect of Changes in Temperature Patterns on Fishing Equipment

The research findings in Table 4.26 revealed that temperature variations have no effect on fishing equipments. The majority of the respondents stated that high temperatures (91.8%), moderate temperatures (98.2%) and low temperatures (99.1%) have no effect on fishing equipment. Temperature unless very extreme is unlikely to cause damage, submergence or destruction of fishing gears/equipments.

4.8.1.3 Effect of Changes in Wind Patterns on Choice of Fishing Equipment

Wind as an aspect of climate variability affects the fishing equipment. The research findings in Table 4.26 above indicated that strong winds often lead to either submergence (80%) or destruction (2.7%) of the fishing equipment while 15.5% of the respondents noted that strong winds have no effect on the fishing gear/equipment. The experience was similar during storms where 62.7% of the respondents stated that fishing equipments get damaged. Nevertheless, only 1.8 % of the respondents pointed out that fishing gear/equipment capsize while 10.9 % said that storm do not affect fishing gear/equipments at all. Notably, 98.2% of the respondents indicated that there is no destruction or submergence of fishing gears/equipments during calm conditions. Thus, calm conditions are most favourable for fishing activities. In support of the above statements, Mahon (2002) observed that the fishing industry of Antigua and Barbuda sustained substantial losses as a result of Hurricane Luis and about 16% of their fleet were either destroyed or lost, and further 18% was totally damaged. During the survey, the fisher-folk indicated that the most affected fishing gears/ equipment's are the boats (canoes) which mostly capsize during heavy storms and strong winds. Likewise, gillnets and seine nets often get damaged under the same circumstances. However, the fisher-folk stated that fishing hooks are not interfered with by wind patterns. On the other hand, 90% and 76.4% of the fisher-folk stated that their fishing gears /equipments are not impacted by floods and droughts respectively.

4.8.2 Impact of Climate Variability on the Fishing Technique

With regards to the impact of climate variability on the fishing technique, the research findings in figure 4.77 below indicate that the majority (80%) of the respondents acknowledged that droughts, storms, flooding and reduction in lake water levels affects their fishing techniques. However, 20% of the respondents stated that droughts, storms, flooding and reduction in lake water levels do not at all affect their fishing techniques.

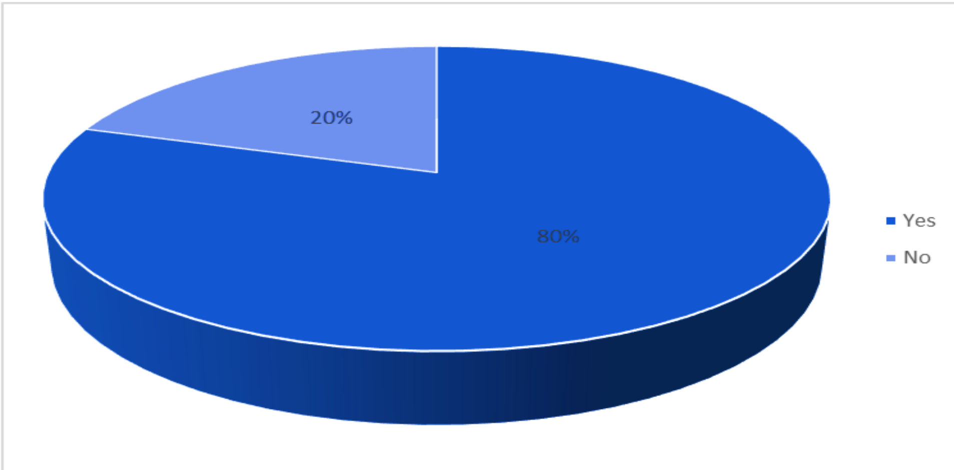

Figure 4.77 : Perceptions of Respondents on Whether or not Climate Variability affects their Fishing Techniques.

Source: Fieldwork data, 2014.

Table 4.27 : Impact of Climate Variability on the Fishing Techniques.

Variability	**Impact**											
	Very high		High		Moderate/ Normal		Low		Very low		No impact	
	f	%	f	%	F	%	F	%	f	%	f	%
High rainfall	52	47.3	22	20	6	5.5	8	7.3	03	0	3	2.7
Moderate rainfall	5	4.5	21	19.1	33	30	25	22.7	3	2.7	3	2.7
Low rainfall	5	4.5	13	11.8	14	11.8	50	45.5	2	1.8	7	6.4
High temperature	6	5.5	2	1.8	5	4.5	26	23.6	10	9.1	41	37.3
Moderate temperature	0	0	4	3.6	14	12.7	25	22.7	7	6.4	40	36.4
Low temperature	16	14.5	15	13.6	13	11.8	26	23.6	7	6.4	13	11.8
Strong winds	43	39.1	30	27.3	0	0	1	0.9	6	5.5	10	9.1
Storm	41	37.3	33	30	0	0	1	0.9	6	5.5	9	8.2
Calm condition	3	2.7	0	0	12	10.9	25	22.7	12	10.9	37	33.6
Flood	16	14.5	3	2.7	24	21.8	36	32.7	4	3.6	5	4.5
Drought	24	21.8	4	3.6	26	23.6	22	20	3	2.7	9	8.2

Source: Fieldwork data, 2014

4.8.2.1 Effect of Changes in Rainfall Patterns on Fishing Technique

With reference to impacts of rainfall patterns on the fishing technique presented in Table 4.27 above, 67.3% of the respondents indicated that high rainfall has greater impact on the fishing technique, 30% noted normal impact during moderate rainfall while 45.5% of the respondents stated that low rainfall often has very low impact on the fishing technique. Floods (22.7%), droughts (32.7%) and calm conditions (33.6%) were noted to have little or no impacts on the fishing technique. During the survey, the fisher-folk indicated that fishing techniques do not change regardless of the changes in weather conditions.

4.8.2.2 Effect of Changes in Wind Patterns on the Fishing Techniques

From the research findings in Table 4.27 above, 66.4 % and 67.3% of the respondents indicated that strong winds and storms influence their fishing techniques respectively. Even though strong winds and storms affect fishing techniques, all of the fisher-folk (100%) use the same type of technique irrespective of the change in weather patterns. During the survey, the fisher-folk stated that they could not afford to use different fishing techniques. This is so because this requires them to buy other fishing gears apart from the usual ones and also they do not earn enough income to be able to purchase other fishing gears that might be needed during the different climatic conditions.

4.8.2.3 Effect of Changes in Temperature Patterns on Fishing Techniques

The research findings in Table 4.27 above revealed that the changes in temperature have no effect on fishing techniques. Thus, 37.3% and 36.4 2% of the respondents indicated that high temperatures and moderate temperatures have no effect on fishing technique respectively. However, 23.6% of the respondents stated that low temperatures have little or no impact on the fishing technique.

4.9 Livelihood, Coping and Adaptive Strategies of the Fisher-folk in the Kafue Flats

Knowledge of fishing as a main stay of peoples' livelihood in Stratum I of the Kafue floodplain fishery was cardinal to this study. According to the CSO (2006) fishery report, fishermen /fishing occupation is categorised into two; full time and part time. In 2006, about 342 fisher-folk were full time while only 16 fisher-folk were part-time (CSO 2006). The CSO (2006) fishery report indicated that out of the five strata found in the Kafue floodplain fishery; stratum II and I have very good/highly productive lagoons namely Chunga, Luwato and Chanyanya. This may encourage more fisher-folk's entry into the fishery as a result of "good fish catches", and may also lead to having more permanent fishing villages (CSO 2006). Thus, the fisher-folk prefer fishing habitats or areas around the lagoons and slow running water bays(CSO 2006).

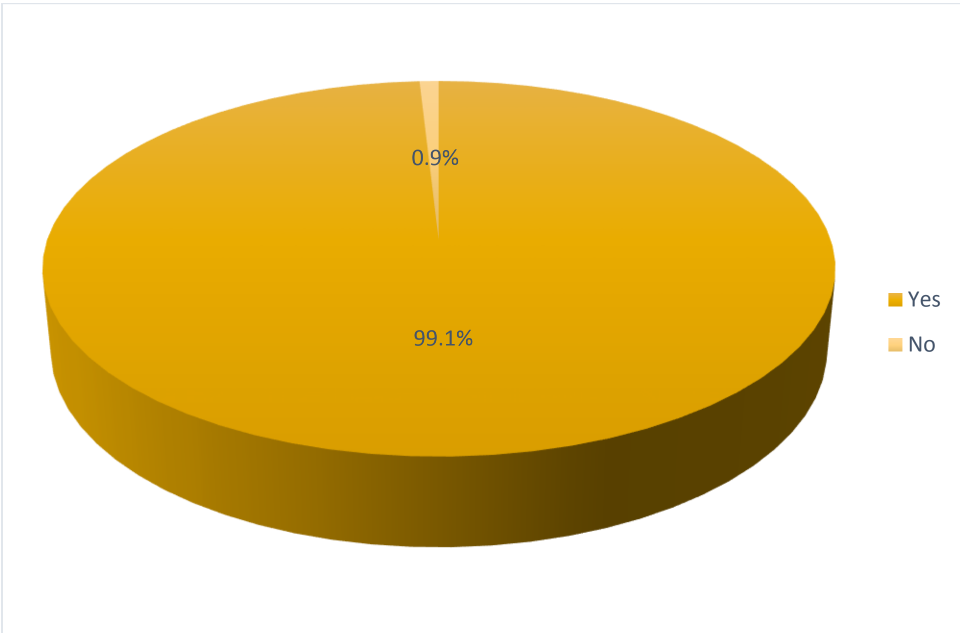

Figure 4.78 : Impact of Climate Variability on the Livelihood of the Fisher-folk.

Source: Fieldwork data, 2014.

Based on the research findings from figure 4.78 above, 99.1% of the respondents indicated that climate variability affects their livelihoods as fishers. However, 0.9% of the respondents hardly noticed any difference in their livelihood in spite of the changes in weather and climate patterns. Badjeck *et al.* (2010) noted that climate variability affects fish species composition, production and yield, risk of health and life of the fisher-folk as well as loss and damage to livelihood assets thereby impacting on the fisher-folk livelihood strategies. Thus, the fisher-folk often have to devise adaptation and mitigation approaches in order to sustain their livelihood. During the survey, the respondents were asked to state how climate variability impacted their livelihood. The research findings presented in Table 4.28 revealed that 98.2% of the respondents had lost their income from fishing, 80.9 % had to abandon fishing at some point for other economic activities, 95.5% experienced reduction in food accessibility as result of loss of revenue from fishing, 60 % encountered conflicts (competing for resources) over fishing areas with their fellow fisher-folk, 90.9 % had to be away from home for some time in search of good fishing sites, 89.1 % had their fishing equipments either destroyed or lost in the waters and 90.9 % had faced malnutrition and under-nutrition risks in their families due to reduced access to fish as a source of proteins. In agreement with the above statements, FAO (2008) noted that fishery-dependent communities are more likely to encounter increased vulnerability in form of reduced stable livelihoods and safety risks as result of fishing in severe weather conditions . Similarly, Norbis *et al.* (2005)and Nagy *et al*. (2006) stated that during strong ENSO years, the net income of the fisher-folk reduced between 40-70% in Uruguay mainly because of the shortened peak period due to inaccessibility of the fisheries and reduction in fish yields.

Table 4.28 : Impact of Climate Variability on the livelihood of the fisher-folk.

Impact of Climate Variability on the livelihood of the Fisher-folk	**Response**			
	Yes		No	
	f	%	f	%
Loss of income from fishing	108	98.2	2	1.8
Had to abandon fishing at some point for other economic activities	89	80.9	21	19.1
Reduced food accessibility due to loss of revenue from fishing	105	95.5	5	4.5
Conflicts with other fisher-folk over fishing areas	66	60	44	40
Fishing equipment destroyed or damaged	98	89.1	12	10.9
Had leave home for a certain period in search of good fishing sites	100	90.9	10	9.1
Loss of membership to fishing co-operative	2	1.8	108	98.2
Risk of malnutrition and under-nutrition by family members due to reduced access to fish a source of protein	100	90.9	10	9.1

Source: Fieldwork data, 2014

4.9.1 Coping and Adaptive Strategies of the Fisher-folk

FAO (2009a) defines adaptation to climate change as "an adjustment in ecological, social or economic systems, in response to observed or expected changes in climatic stimuli". Thus, communities or individuals often take advantage of new opportunities in lessening the severely experienced climate change impacts (FAO 2009a). FAO (2007) noted that many fishers are highly susceptible to widespread disturbances which together reduces their ability to adapt to climate change impacts. Likewise, FAO (2009a) indicated that cultural and socio-economic factors including marginalization often constrain the adaptive capacity of fishing communities in different ways.

With respect to the coping and adaptive strategies, nearly half of the respondents (44.5%) indicated that they do not have other sources of livelihoods apart from fishing as shown in figure 4.79 below. During the survey, the fisher-folk stated that they generally just wait for time to go fishing more especially the rainy season when they are able to catch large amounts of fish for sale and home consumption. This is also supported by the fact that about 342 fisher-folk are full time while only 16 fisher-folk are part-time CSO (2006). Hence, the majority of the fisher-folk depend on fishing as the only livelihood and have no alternative sources of income. However, 28.2% of the respondents stated that they are involved in farming when they are not fishing although farming is only on a small scale. For example, some of the fisher-folk have gardens behind their homes where they grow vegetables, tomatoes, onions and other crops to sustain their lives. Farming as the main supplementary economic activity was not quite viable in the area due to the nature of the soils and scarcity of land. Much of the land in the study area is residential land. Nonetheless, 13.6% of the respondents take up small scale businesses such as shops selling groceries, mealie-meal, cooking oil and soap to their fellow fisher-folk. Thus, they are able to survive during the times that prove difficult in catching fish. Conversely, 10% of the respondents are involved in fish trading while 1.8 % take up carpentry as alternative sources of livelihood aside fishing (See figure 4.79). In addition, another 1.8% of the respondents indicated that they repair damaged boats for other fisher-folk who pay them money. Henceforth, boat repairing is seen as an adaptive strategy.

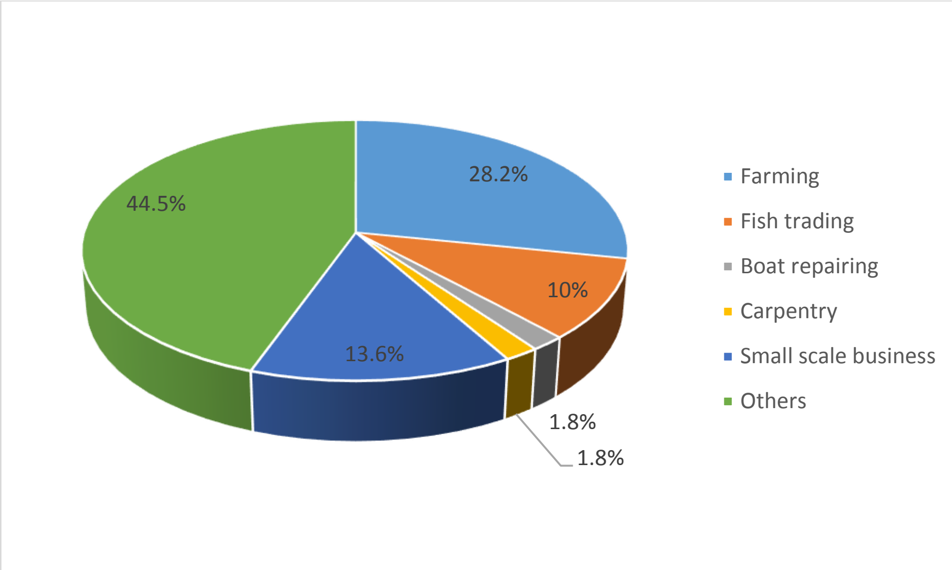

Figure 4.79 : The Coping and Adaptive Strategies of the Fisher-folk.

Source: Fieldwork data, 2014.

Overall, the respondents' assessment on how climate variability affects their livelihoods was overwhelming. The majority indicated that it drastically reduces their income as they are incapable of making enough profits because they do not catch large amounts of fish due to climatic disturbances. By and large, the fisher-folk were of the view that climate variability negatively impacts their livelihoods and as such most of the fisher-folk do not have alternative sources of livelihood. Henceforward, adaptation measures such as responsive or anticipatory actions by individuals and public institutions are required in dealing with climate change impacts (FAO 2009a).

4.10 Chapter Summary

The monthly, seasonal and annual analysis of rainfall and temperature in the Kafue eco-region depicted both upward and downward trends. Notably, monthly and seasonal analysis of rainfall and temperature showed statistically significant increasing and decreasing trends in certain months and seasons. However, annual analysis of both rainfall and temperature exhibited no statistically significant trends over the 30 year period. The irregularity in rainfall and temperature patterns pointed a clear indication to climate variability. Consequently, the significant changes in monthly and seasonal rainfall and temperature certainly affects the fishing and livelihood activities of the fisher-folk. The research findings revealed that changes in precipitation, rising water temperatures and reduced primary production often cause reductions in fish stocks. Likewise, strong winds and heavy storms adversely impact on the fisher-folk and their fishing activities through loss of lives and fishing gear resulting from boat submergence. Moreover, aerial changes determined through change detection analysis of satellite images indicated periodic variations in the size of the Kafue Flats catchment area. By and large, the research findings revealed that the direct impacts of climate variability on fishing and livelihood activities of the fisher-folk include damage of fishing infrastructure/equipments, loss of life due to submergence of fishing gears like boats, increased health and safety risks at sea/lake and flooding of fishing communities. In general, most of the fisher-folk have very low adaptive capacities, thus they are highly susceptible to widespread climate change impacts. Notably, nearly half of the fisher-folk in the Kafue Flats do not have other sources of livelihoods apart from fishing.

The next chapter provides a general summary of research findings, conclusion, limitations and recommendations.

CHAPTER 5 : GENERAL SUMMARY OF RESEARCH FINDINGS, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a consolidated summary of all the findings. The chapter further provides conclusions on fisheries and impacts of climate variability as well as how climate variability affects the fishing activities and livelihoods of the fisher-folk. Besides that, the limitations encountered by the researcher are noted and recommendations are also outlined based on the research findings.

5.2 Summary Findings

This study investigated the implications of climate variability on fishing and livelihood activities of the fisher-folk in the Kafue Flats of Zambia. The factors which were examined included how changes in temperature, rainfall and wind affects the amount of fish catch, fishing facilities, fishing techniques and livelihood of the fisher-folk. Analysis of monthly, seasonal and annual rainfall and temperature over the 1982 -2011 period depicted increasing and decreasing trends. Interestingly, monthly and seasonal analysis of both rainfall and temperature showed statistically significant increasing and decreasing trends in certain months and seasons. However, the observed trends in annual rainfall and temperatures were not statistically significant. Rainfall in the Kafue eco-region is highly seasonal with an annual average of 600-900 mm. The summer months of November through February often receive increased rainfall amounts than the rest of the months. The highest seasonal rainfall amounts throughout the 1982-2011 climate regime were recorded during December, January and February (DJF season). Moreover, parts of the Kafue Flats experienced extreme monthly rainfall events in particular years i.e. 1982, 1986, 1987, 1988, 1989, 1991, 1993, 1994, 2000, 2004, 2007, 2008, 2009 and 2011. Furthermore, temperatures in the Kafue eco-region also vary depending on the season. Multi-decadal analysis of monthly and seasonal maximum and minimum temperatures showed both upward and downward trends. Notably, the month of October recorded the highest mean monthly maximum temperature for all the Meteorological stations. Likewise, the month of October depicted statistically significant increasing trends in maximum temperatures throughout the 30 year climate regime. On the other hand, the lowest mean seasonal minimum temperatures were recorded during the JJA seasons for all the Meteorological stations. Generally, the highest temperatures are basically recorded in SON (summer) season while the lowest temperatures are recorded in JJA season (winter). Consequently, the irregularity in rainfall and temperature patterns point clearly to climate variability. Ultimately, the significant changes in monthly and seasonal rainfall and temperature over the Kafue Flats affect the fishing and livelihood activities of the fisher-folk.

Regarding the fisher-folk's perceptions on the effects of climate variability, the research findings indicated that strong winds, storms, high rainfall and floods have adverse effects on fisher-folk and their fishing activities. For instance, 90.9% of the fisher-folk pointed out that heavy stormy rains have the larger potential to wreak havoc and cause death. The research findings further revealed that most fishing activities do not take place during strong winds and heavy storms due to the fear of drowning or damaging of the fishing equipments. Meanwhile, 95.5% of the respondents indicated that fishing activities return to normal during calm weather conditions. However, temperature changes were reported to have very little impact on the fisher-folk. In general, climate variability has an overall impact on the livelihood of the fisher folk. Based on research findings, 98.2% of the respondents had lost their income from fishing. With regards to the coping and adaptive strategies, nearly half of the respondents (44.5%) indicated that they do not have other sources of livelihoods apart from fishing. However, some of the fisher-folk resort to small-scale subsistence farming (28.2%).

5.3 Conclusion

Small scale fisheries are a dependable form of livelihood that can sustain people's lives for as long as they are properly managed. Small scale fisheries thus, substantially contribute to income generation, food security, poverty reduction and sustainable livelihood for millions of people particularly in developing countries like Zambia. In spite of this significant contribution, small scale fisheries are highly susceptible to climate change and variability. At low latitudes for example, increase and decrease in water temperatures and primary production respectively have led to reduced fish stocks in most fisheries. The research findings indicated that climate variability affects the fishing and livelihood activities of the fisher-folk in the Kafue Flats of Zambia. The direct impacts of climate variability on the fisher-folk themselves range from loss of lives, flooding of fishing communities, impact on health, to destruction of fishing equipment's, long duration of fishing, reduced fish catch and change in fishing techniques. Thus, some of the fisher-folk have been forced to seek alternative sources of livelihood such as farming, small scale businesses, carpentry and fish trading but most of these are not sustainable due to prevailing economic conditions and size of investment. Therefore, there is need to enhance resilience and adoption of sustainable mitigation and adaptation strategies.

5.4 Limitations of the study

The researcher encountered four major limitations in this study. The first one is the long distances in reaching out to the fishing communities. For example, Chanyanaya fishing site/village is over 50 Kilometres from Kafue Town and the road to the fishing site is not tarred but gravel hence it was difficult to get there with small vehicles. However, the researcher hired a 4x4 vehicle to overcome this challenge. Secondly, the researcher had encountered problems with Meteorological data obtained from ZMD as most of the parameters had gaps especially the wind speed which in the end the researcher discarded due to so many omissions. Using the excel spreadsheet, the gaps for missing data of both rainfall and temperature was filled in by calculating the median values across the dataset for all the meteorological stations under the study. Thirdly, the researcher faced language barrier in reaching out to some fisher-folks who could not respondent to local dialects familiar to the researcher. Nonetheless, certain research assistants were very helpful with interpretation of the languages. In the process some questions lost the original meaning through the process of interpretation. Last but not the least, the researcher faced the limitation of distrust between the Department of Fisheries and the fisher-folk communities as they initially accused the researcher of being an envoy of the Department of Fisheries to investigate them despite the fact that the researcher had explained to the fisher-folk's that the research was purely for academic purposes. This took time and delicate dialogue before some of the fisher-folk could open up to the interviews. Related to this limitation is the amount of illiteracy among the fisher-folk communities. This hindered the quick administration of the questionnaires as the researcher needed to follow up the questionnaires slowly by explaining the same questions in several ways in order for the respondents to understand. This had a huge hindrance on the time factor. Additionally, it was noted that the fisher-folk had busy schedules as one fisherman exclaimed in Bemba during the interview that "Ba sister endesheniko, mulemposela inshita, ndefwaya ukuya mukwipaya isabi" meaning please be quick with the interview as I need to go fish because time is running out.

5.5 Recommendations

5.5.1 Establishing fishers' associations.

The research findings clearly indicate that climate variability affects the fisher-folk in terms of loss of lives and fishing gear during stormy rains and strong winds. To help identify vulnerability hot spots and develop fishing adaptation strategies, it is vital that the Department of Fisheries forms fishers' associations among the fisher communities. This will help disseminate information on climate variability impacts and build strong relationships that will link the Department Fisheries and the fisher communities. During data collection, the fisher-folk stated that they did not have any associations whatsoever and they blamed the Department of Fisheries in Kafue for not uniting them to form associations. Thus, instituting of such an association will significantly capacitate the fishers to vigilante themselves and rally round Department of Fisheries in conducting climate-risk assessments. Besides, this too would support change agents to discover leadership on the ground for easier communication.

5.5.2 Capacity building

From the research findings, it has been noted that most of the fisher-folk have no alternative livelihood sources once fishing activities are hard hit by climate variability. Usually, climate variability leads to short fishing durations and reduced fish catch. Henceforth, the researcher is of the view that the government through the Department of Fisheries identifies stakeholders and partners to offer technical and financial support to fishing communities in order to alleviate the high poverty levels existing in these communities. Conversely, the majority of the fisher-folk as indicated in this study are covered in poverty traps. The fisher-folk are incapable of mobilizing essential resources to overcome climatic shocks or severe economic situations because of cash liquidity challenges, social exclusion and insufficient access to credit. Therefore, capacity building would assist the fishing communities in finding alternative sources of income during the fish ban period and also in times where extreme weather conditions impact on the fishing activities. The fisher-folk can also escape poverty traps through adequate governance systems, education, insurance and incentive creation. Overall, capacity building will help the fisher-folk to diversify their livelihoods thereby enhancing resilience.

5.5.3 Involvement of fishers at decision making level

The researcher wishes to suggest that the fisher-folk communities through their opinion leadership be involved at the decision-making level as emphasized by (Kapasa 2004). Participatory approaches must be used to reinforce delivery of communication systems, new methods aimed at improving income and food security as well as reduction of poverty levels among the rural poor communities. In turn, this may ensure community participation at all stages to facilitate the fisher-folk communities to own the programmes and take part in national development. Although the small scale fisher-folk fall in the trap of marginalization, there is need to recognise, value and enhance their significant contribution to food security and national economies. Small scale fisheries are underpinned by economic, social and ecological systems. Thus integrated management of these systems could lead to empowerment of the fisher-folk. Consequently, the fisher-folk may take part in decision making with high self-esteem and respect.

5.5.4 Property Rights

Last but not least, there is potential in small scale fisheries which need to be identified and exploited to its maximum for the benefit of the poor rural communities. Swanepoel and De Beer (2012) noted that poverty is largely a rural phenomenon and is rampant among most fisher-folk globally. Thus, people in rural communities are in the deprivation trap; poor, weak, isolated, powerless and vulnerable. They live in rural areas which lack most of the basic facilities such as good roads, good health facilities, education, electricity and many others which urban dwellers enjoy. Since rural communities are deprived in essential and basic infrastructure and requirement, rural areas in turn lack any meaningful development. What is more is noteworthy is that over-fishing has led to reductions in fish productivity and catch in many of the world’s fisheries including the Kafue Flats (Pauly et al. 2002). In Zambia, overfishing or exploitation is often carried out by migrant fishers found in most fishing villages or camps. Therefore, the researcher is of the view that special rights of access be granted to resident fishermen. These fishermen will defend their fishery resources and in turn protect the ecological values and functions of the Kafue swamps.

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APPENDICES

APPENDIX I: FISHERFOLK QUESTIONNAIRE

IMPLICATIONS OF CLIMATE VARIABILITY ON SMALL SCALE FISHING ACTIVITIES AND THE FISHERS' ADAPTIVE CAPACITY IN THE KAFUE FLATS OF ZAMBIA

INTRODUCTION

Date: …….…... /………….. / 2014

My name is Beverly Mushili, a postgraduate student in the Faculty of Natural and Agricultural Sciences at the University of Pretoria. I am conducting a research on the implications of climate variability on small scale fishing activities and the Fishers' adaptive capacity in the Kafue Flats within Kafue district. You have been chosen as one of the key persons knowledgeable about issues of fisheries in the Kafue Flats. You are therefore, kindly requested to answer the questions in this questionnaire. Your participation in this survey is voluntary. This research is purely academic and any information gathered in this survey will only be used for the purposes of research. Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The interview is completely confidential and your name will not be recorded in this Questionnaire.

Should you have any questions regarding this study feel free to contact Dr Daniel Darkey (my Supervisor) on email: daniel.darkey@up.ac.za

Name of district ……………………..

Date of survey: ....

Chiefdom: ....

Village/ Locality Name: ....

Section A: Socio Economic Characteristics

Q1. What is your gender? *(Please tick one)*

1. Male { }
2. Female { }

Q2. What is your age group? *(Please tick one)*

1. Less than 21 years { }
2. 21 - 30 years { }
3. 31 - 40 years { }
4. 41 - 50 years { }
5. Above 50 years { }

Q3. What is your highest level of education? (Please tick one)

1. None { }
2. Primary { }
3. Secondary { }
4. Tertiary { }
5. Other specify………………………………………………………………………

Q4. What is your marital status? *(Please tick one)*

1. Unmarried { }
2. Married { }
3. Divorced { }
4. Widowed { }
5. Separated { }

Q5. For how long have you lived in this chiefdom? *(Please tick one)*

1. 3 years or less { }
2. 4 – 6 years { }
3. 7 – 9years { }
4. 10 years and above { }

Q6. What is your other source of income apart from fishing? *(Please tick one)*

1. Agriculture (farmer) { }
2. Manual work { }
3. Hand out { }
4. Net Mender { }
5. Other specify………………………………………………………………….

Q7. What is your household income?

1. Kr 2000 or less { }
2. 2001 – 6000 { }
3. 6001 – 10,000 { }
4. Above 10,001 { }

Q8. What is your monthly income from fishing? *(Please tick one)*

5. Kr 2000 or less { }
6. 2001 – 6000 { }
7. 6001 – 10,000 { }
8. Above 10,001 { }

Q9. How many people live in your household? *(Please tick one)*

1. 5 or less { }
2. 6 -10 { }
3. More than 10 { }

SECTION B: Impact of climate variability on fishing activities and fishing duration

Q10. Has variability of climate in terms strong winds, high rainfall, storm, drought, flooding, and high temperatures had any effect on your fishing activities *(Please tick one)*

1. Yes { }
2. No { }
3. Not sure { }

Q11. Have the changes in lake water levels in Kafue Flats had any effect on your fishing activity as a fisher-folk? *(Please tick one)*

1. Yes { }
2. No { }
3. Not sure { }

Q12. What is the effect of the different water levels on the amount of fish catch? *(Tick the appropriate box)*

Water Level	Effect				
	Very high	High	Moderate/Normal	Low	Very Low
High water level					
Moderate water level					
Low water level					

Q13. What are the effects of climate variability on the fishing activity of the fisher-folk *(Tick the appropriate box)*

Climate Variability	Effect			
	Loss of life due to boat capsizing	Sickness of fisher folk due to injuries	Loss of fishing gear in water	Other effects (specify)
High rainfall				
Moderate rainfall				
Low rainfall				
High temperature				
Moderate temperature				
Low temperature				
Strong winds				
Storm				
Calm condition				

Flood
Drought

Q14. What are the effects of climate variability on fishing duration? *(Tick the appropriate box)*

Climate Variability	Time period			
	Long time period	Normal time period	Short time period	No fishing at all
High rainfall				
Moderate rainfall				
Low rainfall				
High temperature				
Moderate temperature				
Low temperature				
Strong winds				
Storm				
Calm condition				
Flood				
Drought				

Section C: Impact of climate variability on the amount of fish catch

Q15. Indicate the types of fish caught in the Kafue Flats *(Tick the appropriate box)*

Type of Fish
Kapenta (" *Limnothrissa miodon*")
Mpende ("*Tilapia rendalli* ")
Imilonge (Bubble fish)
Mintesa ("*Marcusenius macrolepidotus*")
Matuku ("*Tilapia sparmanii* ")
Shilutungu ("*Schilbe intermedius*")
Michena ("Hepsetus odoe")
Nkolokolo ("Synondotis kafuensis")
Mpumbu ("Labeo altivelis")
Bottle fish
Others (specify)

Q16. What is the amount of fish catch for each type of fish? (*Tick the appropriate box)*

Quantity

Type of fish				
	High	Moderate (Normal)	Low	No catch
Kapenta (" *Limnothrissa miodon*")				
Mpende ("*Tilapia rendalli* ")				
Imilonge (Bubble fish)				
Mintesa ("*Marcusenius macrolepidotus*")				
Matuku ("*Tilapia sparmanii* ")				
Shilutungu ("*Schilbe intermedius*")				
Michena ("Hepsetus odoe")				
Nkolokolo ("Synondotis kafuensis")				
Mpumbu ("Labeo altivelis")				
Bottle fish				
Others (specify)				

Q17. Does the amount of fish catch remain constant irrespective of climate variation?

1. Yes { }
2. No { }
3. Not sure { }

Q18. Indicate the impact of the following climate variability elements on the amount of fish catch within the Kafue Flats. *(Tick the appropriate box)*

Climate Variability	**Impact**					
	Very high	High	Moderate/Normal	Low	Very low	No Impact
High rainfall						
Moderate rainfall						
Low rainfall						
High temperature						
Moderate temperature						
Low temperature						
Strong winds						
Storm						
Calm condition						
Flood						

Drought

Section D: Impact of climate variability on fishing techniques

Q19. What types of fishing gear do you use to catch fish? *(Tick the appropriate box)*

Type of Gear
Boat
Hooks
Seine nets
Gill nets
Others (specify)

Q20. What are the effects of climate variability on your fishing gear (boats, hooks, gill nets, seine nets etc.) *(Tick the appropriate box)*

Climate Variability	**Effect**		
	Capsized	Damaged	No effect
High rainfall			
Moderate rainfall			
Low rainfall			
High temperature			
Moderate temperature			
Low temperature			
Strong winds			
Storm			
Calm condition			
Flood			
Drought			

Q21. Do you use the same type of gear irrespective of the change in climatic conditions?

1. Yes { }
2. No { }
3. Not sure { }

Q22. Has variability of climate in terms of drought, storm, flooding, and reduction in lake water levels had any effect on your fishing techniques *(Please tick one)*

4. Yes { }
5. No { }

6. Not sure { }

Q23. Indicate the impact of the following climate variability elements on fishing technique within the Kafue Flats *(Tick the appropriate box)*

Climate Variability	**Impact**					
	Very high	High	Moderate/Normal	Low	Very low	No Effect
High rainfall						
Moderate rainfall						
Low rainfall						
High temperature						
Moderate temperature						
Low temperature						
Strong winds						
Storm						
Calm condition						
Flood						
Drought						

Section E: Effect of climate variability on the livelihood of the fisher-folk

Q24. Has variability of climate in terms of drought, flooding, storm and reduction in lake water levels had any effect on your livelihood as a fisher folk *(Please tick one)*

1. Yes { }
2. No { }

Q25. What impacts has climate variability had on your livelihood? *(Please tick all those that apply)*

1. Loss of income from fishing { }
2. Had to abandon fishing at some point for other economic activities { }
3. Reduced food accessibility due to loss of revenue from fishing { }
4. Conflict with other fisher folk over fishing areas { }
5. Fishing equipment damaged or lost { }

6. Had to leave home for a certain period in search of good fishing sites { }
7. Loss of membership to fishing cooperative { }
8. Risk of malnutrition and under-nutrition by family members due to reduced access to fish as a source of protein. { }
9. Other specify…………………………………………………………………..........

……………………………………………………………………………………..

……………………………………………………………………………………....

Q26. What are your coping and adaptive strategies? *(Please tick all those that apply)*

1. Farming { }
2. Fish trading { }
3. Boat repairing { }
4. Carpentry { }
5. Small scale business { }
6. Others (specify)…………………………………………………………………

………………………………………………………………………………………

Q27. Comment on how your adaptive strategy has impacted on your livelihood? ....

…………………………………………………………………………………..…

………………………………………………………………………………….

…………………………………………………………………………………….

Q28. Do you have any further comments in relation to the implications of climate variability on small scale fishing activities? ....

……………………………………………………………………………………..

…………………………………………………………………………….........

We have come to the end of the interview.

Thank you very much for your time and God bless you.

APPENDIX II: INTERVIEW GUIDE FOR OFFICIALS FROM METEOROLOGICAL DEPARTMENT

IMPLICATIONS OF CLIMATE VARIABILITY ON SMALL SCALE FISHING ACTIVITIES AND THE FISHERS' ADAPTIVE CAPACITY IN THE KAFUE FLATS OF ZAMBIA

INTRODUCTION

Date: ……........ /………….. / 2014

My name is Beverly Mushili, a postgraduate student in the Faculty of Natural and Agricultural Sciences at the University of Pretoria. I am conducting a research on the implications of climate variability on small scale fishing activities and the Fishers' adaptive capacity in the Kafue Flats within Kafue district. You have been chosen as one of the key persons knowledgeable about issues of fisheries in the Kafue Flats. You are therefore, kindly requested to answer the questions in this questionnaire. Your participation in this survey is voluntary. This research is purely academic and any information gathered in this survey will only be used for the purposes of research. Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The interview is completely confidential and your name will not be recorded in this Questionnaire.

Should you have any questions regarding this study feel free to contact Dr Daniel Darkey (my Supervisor) on email: daniel.darkey@up.ac.za .

Name of district ……………………..

Date of survey: ....

Section A: Personal Information

Q1. What is your gender? *(Please tick one)*

Male { }

Female { }

Q2. What is your age group? *(Please tick one)*

1. Less than 21 years { }
2. 21 - 30 years { }
3. 31 - 40 years { }
4. 41 - 50 years { }
5. Above 50 years { }

Q3. Qualification …………………………………………………………

Q4. Field of specialization ……………………………………………..

Q5. Position …………………………………………………………………

Q6 Duration of service in this position ………………………………….

Q7. Total Length of service ……………………………………………….

Section B: Trends in Climate Variability

a) What climatic conditions have been experienced in the Kafue Flats for the period 1982 - 2012?

……………………………………………………………………….......

……………………………………………………………………….....

……………………………………………………………………….....

……………………………………………………………………….....

b) What have been the temperature trends for the Kafue Flats for the period 1982 - 2012? ………………………………………………………………………………...

…………………………………………………………………………………………

………………………………………………………………………………………...

……………………………………………………………………………………………

c) What have been the rainfall trends for the Kafue Flats for the period 1982 - 2012?

……………………………………………………………………………………………..

……………………………………………………………………………………………......

……………………………………………………………………………………………..

……………………………………………………………………………………………..

d) Do the changes in climatic conditions have any impact on the Kafue Flats?

……………………………………………………………………………………………..

……………………………………………………………………………………………......

……………………………………………………………………………………………..

……………………………………………………………………………………………..

e) What is the severity of the climatic conditions over the Kafue Flats?

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………......

……………………………………………………………………………………………..

We have come to the end of the interview.

Thank you very much for your time and God bless you.

APPENDIX III: INTERVIEW GUIDE FOR OFFICIALS FROM FISHERIES DEPARTMENT

IMPLICATIONS OF CLIMATE VARIABILITY ON SMALL SCALE FISHING ACTIVITIES AND THE FISHERS' ADAPTIVE CAPACITY IN THE KAFUE FLATS OF ZAMBIA

INTRODUCTION

Date: ……........ /………….. / 2014

My name is Beverly Mushili, a postgraduate student in the Faculty of Natural and Agricultural Sciences at the University of Pretoria. I am conducting a research on the implications of climate variability on small scale fishing activities and the Fishers' adaptive capacity in the Kafue Flats within Kafue district. You have been chosen as one of the key persons knowledgeable about issues of fisheries in the Kafue Flats. You are therefore, kindly requested to answer the questions in this questionnaire. Your participation in this survey is voluntary. This research is purely academic and any information gathered in this survey will only be used for the purposes of research. Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The interview is completely confidential and your name will not be recorded in this Questionnaire.

Should you have any questions regarding this study feel free to contact Dr Daniel Darkey (my Supervisor) on email: daniel.darkey@up.ac.za .

Name of district ……………………..

Date of survey: ....

Section A: Personal Information

Q1. What is your gender? *(Please tick one)*

1. Male { }
2. Female { }

Q2. What is your age group? *(Please tick one)*

1. Less than 21 years { }
2. 21 - 30 years { }
3. 31 - 40 years { }
4. 41 - 50 years { }
5. Above 50 years { }

Q3. Qualification ………………………………………………………

Q4. Field of specialization ……………………………………………..

Q5. Position ……………………………………………………………

Q6 Duration of service in this position ………………………………….

Q7. Total Length of service ……………………………………………………

Q8. What is your role in fisheries management in the Kafue Flats? ....

…………………………………………………………………………………………….

…………………………………………………………………………………………….

Section B: Impact of climate variability on small scale fishing and the fishers' adaptive capacity

Comment on the following in relation to climate variability and fishing in your area of jurisdiction.

(a) Trends in the amount of fish catch in the Kafue Flats over the period 1982 -2012………..
…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

(b) Fishing gear/techniques adopted by fisher folk……………………………………

…………………………………………………………………………………………......

…………………………………………………………………………………………….

…………………………………………………………………………………………….

(c) Effects of climate variability on small scale fishing activities…………………………..…

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

(d) Effect of climate variability on fishing duration………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

(e) Periodic variation in water volume and size of the Kafue Flats…………………..

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

(f) Livelihood activities of the fisher folk…………………………………………………..

……………………………………………………………………………………………

…………………………………………………………………………………………......

…………………………………………………………………………………………….

(g) Effect of climate variability on fisher-folk livelihood....…………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

(h) Conflicts in small scale fishing industry…………….……………………………………

…………………………………………………………………………………………….

…………………………………………………………………………………………......

…………………………………………………………………………………………….

(i) Any further comments in relation to the implications of climate variability on small scale fishing activities? ....

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

We have come to the end of the interview.

Thank you very much for your time and God bless you.

APPENDIX IV: INTERVIEW GUIDE FOR THE TRADITIONAL LEADER

IMPLICATIONS OF CLIMATE VARIABILITY ON SMALL SCALE FISHING ACTIVITIES AND THE FISHERS' ADAPTIVE CAPACITY IN THE KAFUE FLATS OF ZAMBIA

INTRODUCTION

Date: ……........ /………….. / 2014

My name is Beverly Mushili, a postgraduate student in the Faculty of Natural and Agricultural Sciences at the University of Pretoria. I am conducting a research on the implications of climate variability on small scale fishing activities and the Fishers' adaptive capacity in the Kafue Flats within Kafue district. You have been chosen as one of the key persons knowledgeable about issues of fisheries in the Kafue Flats. You are therefore, kindly requested to answer the questions in this questionnaire. Your participation in this survey is voluntary. This research is purely academic and any information gathered in this survey will only be used for the purposes of research. Please respond as honestly as you can to all the questions. Feel free to make further comments you may want to. The interview is completely confidential and your name will not be recorded in this Questionnaire.

Should you have any questions regarding this study feel free to contact Dr Daniel Darkey (my Supervisor) on email: daniel.darkey@up.ac.za

Name of district ……………………...

Date of survey: ....

Chiefdom: ....

Village: ....

Section A: Personal Information

Q1. What is your gender? *(Please tick one)*

1. Male { }
2. Female { }

Q2. What is your age group? *(Please tick one)*

1. Less than 21 years { }
2. 21 - 30 years { }
3. 31 - 40 years { }
4. 41 - 50 years { }
5. Above 50 years { }

Q3. What is your role in the management of fisheries in the Kafue Flats? ....

…………………………………………………………………………………………………

…………………………………………………………………………………………

Section B: Information in relation to impacts of climate variability on small scale fisheries

Q4. Has there been changes in the fishing activities in the Kafue Flats over the period 1982 -2012?

....

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………

Q5. What has caused such changes? ....

………………………………………………………………………………………………..

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

Q6. What impacts do the changes in the fishing activities have on the livelihoods of the local people in the Kafue Flats? ....

…………………………………………………………………………………………......

………………………………………………………………………………………………..

…………………………………………………………………………………………......

Q7. What are the alternative sources of livelihood apart from fishing? ....

…………………………………………………………………………………………......

………………………………………………………………………………………………..

………………………………………………………………………………………………..

Q8. Have you experienced any conflicts in the small scale fishing industry among fishermen?

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

Q9. What are the causes of conflicts in the small scale fishing industry among fishermen? ......

………………………………………………………………………………………………..

…………………………………………………………………………………………......

……………………………………………………………………………………………….

We have come to the end of the interview.

Thank you very much for your time and God bless you.

APPENDIX V: CONSENT AND ASSENT FORMS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Natural and Agricultural Sciences

Date……………………………………

A - INFORMED CONSENT TO PARTICIPANTS (OFFICIALS FROM THE DEPARTMENT OF FISHERIES, ZAMBIA METEOROLOGICAL DEPARTMENT AND LOCAL FISHER-FOLK (MEN, WOMEN AND TRADITIONAL LEADERS)

I am a Master's student in the Faculty of Natural and Agricultural sciences, University of Pretoria. I am currently working on a research project entitled '**Implications of Climate Variability on Small Scale Fishing Activities and the Fishers' Adaptive Capacity in the Kafue Flats of Zambia'.** The study intends to analyse the implications of climate variability, specifically observed changes in rainfall, temperature and wind on the fishing activities and fishing duration, amount of fish catch, the choice of fishing techniques/gear and the livelihoods of the fishing communities in the Kafue Flats within Kafue District.

For the purpose of this study, I kindly request you to participate in an interview discussion. Your participation will enable me collect relevant information that will help me achieve the goals of the study. I therefore request you to read the information provided below before you make an informed decision regarding your participation in this study.

RESEARCH PROCEDURE

1. Title: "**Implications of Climate Variability on Small Scale Fishing Activities and the Fishers' Adaptive Capacity in the Kafue Flats of Zambia".**

2. Purpose of the study: The purpose of the study is to obtain knowledge of how fisher-folk perceive and understand the impacts of climate variability on fishing activities and their livelihood. The mechanisms used by the fisher-folk to respond to climatic shocks are important in order to address the problem of climate change thus providing the capabilities for mitigation and adaptation strategies.

3. Procedures: Semi-structured and structured interviews will be conducted within an hour each. During this process, you are allowed to withdraw either yourself and/or your contribution at any time you wish to do so. You will not be forced to provide information related to this study. All information that you supply will remain confidential and your identity will not be revealed to other participants or in the final draft report. Furthermore, with your consent I will record our conversation to allow me to capture all useful information and to be able to cross-check the authenticity of the recorded information. A written draft of our interview will be sent to you to amend or confirm before I use it as data in my study.

4. Benefits: The findings of the study are expected to be useful to the government, policy makers and the wider society on how to address the risks posed to the fisher-folk by the impacts of climate variability. This is so because in Zambia, the fishing sector is mostly of rural setting. The mechanisms by which small scale fishing communities respond to climate variability will also provide valuable insights into how communities affected in future might adapt and cope with the impacts of climate variability.

DECLARATION

I... (Name) of... (Address) agree to participate in the study mentioned above. I understand that I have the right to withdraw myself from participating in the study at any time when I feel to do so.

YES	**NO**

I understand that my personal information and identity will be kept confidential and it will not be disclosed without my authority.

YES	**NO**

I am giving my consent fully aware of the possible risks that may be associated with this study.

YES	**NO**

Participant's name....................................Signature............................Date..........................

Beverly Musonda Mushili **Signature..**

M.Sc. (Environment and Society),

Faculty of Natural and Agricultural Science,

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Pretoria,

0002,

Republic of South Africa

Mobile: +27 728077437 (South Africa).

+260979025615 (Zambia)

Email: mushili.beverly2@gmail.com

Dr Daniel Darkey **Signature..**

Supervisor

Centre for Environmental Studies (CFES)

Faculty of Natural and Agricultural Sciences

University of Pretoria

Pretoria

0002

Republic of South Africa

Email: daniel.darkey@up.ac.za

APPENDIX VI: TABLES SHOWING MONTHLY RAINFALL AND TEMPERATURE DATA FOR ALL METEOROLOGICAL STATIONS ANALYSED USING ANCLIM SOFTWARE

Table 1: Temperature and Rainfall Data for Lusaka City Station

Maximum Temperature (° C)

Months	Arithmetic Mean	Highest Value	Year	Lowest Value	Year	Standard deviation	Covariance	TL@95%	Decadal changes	Magnitude of change	Mann Kendall
JAN	26.5967	28.1	2003	24.6	1986	0.9114	3.43	0.396	0.077	0.077	0.021
FEB	26.5100	29.8	1992	24.9	1989	0.9564	3.61	0.783	0.159	0.0159	0.076
MAR	26.9867	31.8	2009	21.3	2007	1.6948	6.28	-0.113	-0.041	-0.0041	-0.016
APR	26.5067	28.7	1995	24.6	1986	1.1776	4.44	0.197	0.050	0.0050	-0.016
MAY	25.1633	26.9	1983	22.8	2000	1.0947	4.35	0.799	0.186	0.0186	0.090
JUN	23.4500	25.5	1998	21.6	1986	0.9857	4.20	1.421	0.290	0.0290	0.136
JUL	23.0400	25.0	1990	22.6	1993	0.64	2.81	-0.430	-0.060	-0.0060	-0.126
AUG	25.8600	28.2	2005	24.2	1985	0.9997	3.87	2.521	0.489	0.0489	0.246
SEP	29.4600	30.9	2008	27.3	1982	0.8020	2.72	1.894	0.307	0.0307	0.085
OCT	30.9200	33.1	2010	28.4	1982	1.2377	4.00	2.446	0.590	0.0590	0.237
NOV	29.8733	32.3	1994	27.9	1984	1.1682	3.91	0.978	0.241	0.0241	0.103
DEC	27.0633	28.7	1994	25.1	1984	0.9183	3.54	-0.003	-0.001	-0.0001	-0.057

Minimum Temperature (° C)

JAN	17.3567	18.8	1984	14.6	2004	0.7886	4.54	-0.707	-0.119	-0.0119	-0.122
FEB	16.8333	17.8	1996	15.6	2011	0.6055	3.60	0.198	0.026	0.0026	0.011
MAR	16.6567	19.1	2007	15.3	1982	0.8484	5.09	1.099	0.196	0.0196	0.080
APR	15.1200	17.0	1994	13.3	1985	1.3020	6.83	-0.362	-0.080	-0.0080	-0.067
MAY	12.8133	17.0	1994	10.3	2003	1.2266	9.57	-1.235	-0.317	-0.0317	-0.195

JUN	10.7767	17.0	1994	8.2	1987	1.4855	13.78	0.340	0.108	0.0108	0.076
JUL	10.3900	17.0	1994	8.0	1990	1.4997	14.43	-0.221	-0.071	-0.0071	-0.136
AUG	12.4733	17.0	1994	9.1	1990	1.4027	11.25	0.947	0.281	0.0281	0.131
SEP	15.4300	17.0	1994	12.4	1990	0.9014	5.84	0.236	0.046	0.0046	-0.053
OCT	17.5567	18.9	1995	15.8	1989	0.8182	4.66	1.963	0.323	0.0323	0.228
NOV	17.8800	19.7	1983	16.2	1985	0.8656	4.84	0.108	0.020	0.0020	-0.002
DEC	17.3367	18.8	1984	14.6	2004	0.7886	4.54	0.707	-0.119	-0.0119	-0.122

Rainfall (mm)

JAN	229.4833	412.1	1989	91.8	1995	92.7120	40.40	0.266	5.293	0.5293	0.016
FEB	178.8400	419.9	1989	37.4	2002	97.5414	54.54	0.147	3.084	0.3084	0.021
MAR	89.1400	225.0	2000	5.6	1994	61.3467	68.82	1.991	24.541	2.4541	0.255
APR	28.9167	181.0	1986	0.0	1987	49.1950	170.13	1.462	-14.883	-1.4883	0.352
MAY	2.3433	39.1	2009	0.0	1983	7.6085	324.69	0.892	1.436	0.1436	-0.752
JUN	0.2333	7.0	2000	0.0	1982	1.2780	547.72	0.398	0.109	0.0109	-0.917
JUL	0.0067	0.2	1988	0.0	1982	0.0365	547.72	-0.981	-0.008	-0.0008	-0.972
AUG	0.0233	0.7	1989	0.0	1982	0.1278	547.72	-0.863	-0.023	-0.0023	-0.968
SEP	0.05067	7.2	1993	0.0	1983	2.1862	291.82	-0.868	-0.272	-0.0272	-0.811
OCT	12.6533	54.3	1982	0.0	1993	17.6988	139.88	-1.505	-5.499	-0.5499	-0.366
NOV	73.2933	181.5	2009	10.0	1988	42.2506	57.65	3.005	23.702	2.3702	**0.292**
DEC	186.0467	469.9	2004	19.9	1995	92.3131	49.2	0.957	18.666	1.8666	0.094

Table 2: Temperature and Rainfall Data for Mumbwa Station

Months	Arithmetic Mean	Highest Value	Year	Lowest Value	Year	Standard deviation	Covariance	LT@ 95%	Decadal changes	Magnitude of change	Mann Kendall
Maximum Temperature (° C)											
JAN	27.4867	29.7	1992	26.0	1987	0.8737	3.18	-0.467	-0.087	-0.0087	-0.117
FEB	27.6767	31.3	1992	26.1	1989	0.9995	3.61	0.570	0.122	0.0122	0.062
MAR	27.8867	31.3	1994	26.4	1997	0.9888	3.55	-0.019	-0.004	-0.0004	-0.025
APR	27.8133	29.7	1987	26.5	1985	0.9822	3.53	-0.674	-0.141	-0.0141	-0.076
MAY	26.8700	28.5	1983	24.9	1986	0.8883	3.31	1.130	0.211	0.0211	0.053
JUN	25.1867	26.5	2009	23.3	1986	0.8435	3.35	1.582	0.275	0.0275	0.030
JUL	24.9067	28.5	2002	23.3	2009	1.1160	4.48	0.496	0.118	0.0118	0.039
AUG	27.4033	32.6	1996	25.7	2000	0.9219	3.36	1.384	0.265	0.0383	0.131
SEP	31.1100	32.6	2008	27.6	1982	0.9887	3.18	1.574	0.320	0.0320	0.053
OCT	32.8100	43.2	2005	29.6	1986	2.3273	7.09	2.615	1.171	0.1171	0.338
NOV	30.7833	33.2	1987	28.7	1986	0.9660	3.14	0.130	0.027	0.0027	0.011
DEC	27.9667	29.6	1982	26	1984	0.8434	3.02	0.805	0.144	0.0144	0.002
Minimum Temperature (° C)											
JAN	17.5800	18.6	1995	16.5	2010	0.5061	2.88	-0.312	-0.034	-0.0034	-0.172
FEB	17.2500	18.1	1998	15.9	1986	0.5111	2.96	1.763	0.184	0.0184	0.126
MAR	16.5233	18.1	1998	15.1	1994	0.6947	4.20	0.919	0.135	0.0135	0.039
APR	14.0567	15.9	2010	12.0	1991	0.8780	6.25	0.706	0.132	0.0132	-0.011
MAY	10.3733	13.1	1995	5.0	2005	1.6150	15.57	0.619	0.213	0.0213	0.085
JUN	8.0500	9.8	1983	4.1	1987	1.4422	17.92	2.180	0.624	0.0624	0.241

JUL	7.8333	10.6	1992	4.8	1986	1.2169	15.54	0.975	0.251	0.0251	0.057
AUG	10.7800	12.9	2001	8.6	2000	1.092	10.17	0.515	0.121	0.0121	0.067
SEP	14.3100	17.9	1987	1.4	1998	2.8461	19.89	-0.775	-0.469	-0.0467	-0.159
OCT	17.4433	20.2	1995	10.0	2005	1.7524	10.05	0.004	0.002	0.0002	0.131
NOV	17.8833	20.1	1996	11.0	2005	1.5942	8.91	-1.103	-0.370	-0.0370	-0.113
DEC	17.6133	18.6	2008	12.0	2005	1.1491	6.52	-0.663	-0.162	-0.0162	-0.034

Rainfall (mm)

JAN	207.0367	457.1	1989	12.2	2003	121.2215	58.55	-0.421	-10.930	-1.0930	-0.048
FEB	162.4900	449.1	1989	0.0	2009	104.4538	64.28	-2.223	-45.949	-4.5949	-0.274
MAR	95.2033	251.8	2000	0.0	1992	66.3233	69.66	-0.779	-10.975	-1.0975	-0.136
APR	16.9100	151.6	1986	0.0	1987	36.3277	214.80	-1.410	-10.627	-1.0627	-0.439
MAY	2.5333	41.0	1987	0.0	1984	8.5684	338.22	-1.225	-2.196	-1.2196	-0.793
JUN	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
JUL	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
AUG	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
SEP	7.5900	207.5	2009	0.0	1983	37.8087	498.14	1.435	11.238	1.1238	-0.646
OCT	33.1200	278.8	2009	0.0	1983	54.7673	165.36	0.169	1.981	0.1981	-0.287
NOV	95.5100	493.3	2011	0.0	1993	94.1626	95.59	2.061	38.825	3.8825	0.154
DEC	196.0967	431.7	2011	21.6	2008	91.7882	46.81	0.976	18.912	1.8912	0.076

Table 3: Temperature and Rainfall Data for Kafue Polder Station

Months	Arithmetic Mean	Highest Value	Year	Lowest Value	Year	Standard deviation	Covariance	LT@ 95%	Decadal changes	Magnitude of change	Mann Kendall
Maximum Temperature (° C)											
JAN	28.7033	30.8	1995	26.9	1990	0.9651	3.36	-0.681	-0.140	-0.0140	-0.113
FEB	29.1633	33.1	1992	26.4	2001	1.3798	4.73	0.928	0.271	0.0271	0.117
MAR	29.4367	31.6	1987	27.4	2001	1.1494	3.90	-0.963	-0.234	-0.0234	-0.159
APR	29.2200	31.4	1987	27.4	1989	1.1889	4.07	0.589	-0.149	-0.0149	-0.039
MAY	27.9300	30.0	1983	25.8	2000	0.9827	3.52	-0.233	-0.049	-0.0049	-0.030
JUN	26.0100	28.8	2008	24.3	1986	1.0090	3.88	0.688	0.143	0.0143	0.030
JUL	25.4967	28.0	2002	24.0	2000	0.8783	3.44	-1.123	-0.207	-0.0207	-0.18
AUG	28.0867	30.3	2005	26.1	2000	0.9317	3.32	0.129	0.026	0.026	-0.044
SEP	31.7700	33.2	1995	29.6	2006	0.9203	2.90	-1.188	-0.229	-0.0229	-0.186
OCT	33.3367	35.4	1992	31.1	1982	1.2475	3.74	1.442	0.373	0.0373	0.195
NOV	32.2233	34.9	1994	30.2	1986	1.1497	3.57	-0.096	-0.024	-0.0024	0.011
DEC	32.2233	34.9	1994	30.2	1986	1.1497	3.57	-0.777	-0.159	-0.0159	-0.131
Minimum Temperature (° C)											
JAN	18.4833	19.8	1998	17.2	2009	0.5790	3.13	0.141	0.018	-0.0018	-0.154
FEB	18.2733	19.3	1998	15.8	2011	0.710	3.89	0.160	0.024	0.0024	0.062
MAR	17.2500	18.4	1998	15.2	1994	0.7583	4.40	0.133	0.022	0.0022	-0.126
APR	14.4267	15.7	1988	12.8	1991	0.6873	4.76	-0.902	-0.131	-0.0131	-0.223
MAY	10.4367	13.6	1995	6.9	2005	1.3436	12.86	-2.036	-0.548	-0.0548	-0.269
JUN	7.8967	17.2	2008	5.7	2003	2.2636	28.66	-0.377	-0.183	-0.0183	-0.283
JUL	7.6667	9.8	1999	5.3	2011	0.9193	11.99	-0.519	-0.102	-0.0102	-0.117
AUG	10.1267	13.1	1987	6.0	2011	1.4902	14.72	-0.854	-0.270	-0.0270	-0.034
SEP	13.8233	16.9	1987	9.8	2011	1.3237	9.58	-3.795	-0.876	-0.0876	-0.416

OCT	17.3133	19.5	1984	14.5	2011	1.0935	6.32	-3.795	-0.613	-0.0613	-0.375
NOV	18.5600	19.8	1998	17.3	2010	0.6616	3.56	-3.003	-0.241	-0.0241	-0.287
DEC	18.7233	19.8	1987	17.0	1986	0.5399	2.88	-1.793	-0.058	-0.0058	-0.264

Rainfall (mm)

JAN	199.4000	578.5	1990	80.7	1995	100.4607	50.38	-0.145	-8.928	-0.8928	-0.021
FEB	146.4633	516.0	1989	31.9	2005	89.5953	61.17	-0.393	-7.541	-0.7541	-0.011
MAR	90.9967	525.6	2003	7.3	1982	93.8304	103.11	1.834	34.911	3.4911	-0.255
APR	25.4300	158.3	2002	0.0	1985	45.0788	177.27	0.420	4.054	0.4054	0.034
MAY	1.2900	19.9	2000	0.0	1983	4.4218	342.78	0.141	0.134	0.0134	0.807
JUN	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1-000
JUL	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
AUG	0.0200	0.6	1999	0.0	1982	0.1095	547.72	0.284	0.007	0.0007	-0.922
SEP	0.5133	8.1	1997	0.0	1983	1.9564	381.11	-1.102	-0.453	-0.0453	-0.931
OCT	26.5900	166.0	1986	0.0	1984	39.5220	148.63	-1.714	-13.832	-1.3832	-0.315
NOV	68.5933	149.3	1993	5.5	1983	37.8123	55.13	0.802	6.435	0.6435	0.071
DEC	157.1067	319.7	2005	50.8	1982	63.8688	40.65	1.228	16.400	1.6400	0.044

Table 4: Temperature and Rainfall Data for Magoye Station

Months	Arithmetic Mean	Highest Value	Year	Lowest Value	Year	Standard deviation	Covariance	LT@95%	Decadal changes	Magnitude of change	Mann Kendall
Maximum Temperature (° C)											
JAN	28.8967	31.2	2003	27.1	1989	1.1272	3.90	0.017	0.004	0.0004	-0.053
FEB	29.0567	33.2	1992	26.6	1989	1.2840	4.42	0.856	0.233	0.0233	0.117
APR	29.1233	31.5	1995	27.4	1996	1.1337	3.89	-0.449	-0.109	-0.0109	-0.062
MAY	29.9033	31.6	1995	26.9	1986	1.1260	3.90	-0.435	-0.105	-0.0105	-0.053
JUN	27.6967	30.2	2005	25.8	2004	1.0536	3.80	0.362	0.082	0.0082	-0.011
JUL	25.7700	27.7	2005	24.2	1986	0.8878	3.45	0.629	0.119	0.0119	0.048
AUG	25.5033	2.7	2002	23.6	2009	0.9000	3.53	-0.618	-0.119	-0.0119	-0.094
SEP	28.3133	30.8	2005	26.8	1983	0.9130	3.22	2.149	0.390	0.0390	0.186
OCT	32.1467	33.1	1991	30.0	1982	0.8245	2.56	0.584	0.103	0.0103	-0.067
NOV	33.5733	35.7	2010	30.9	1986	1.2747	3.80	2.517	0.622	0.0622	0.260
DEC	32.1333	35.2	1987	29.0	2000	1.1684	3.64	-0.032	-0.008	-0.0008	-0.007
Minimum Temperature (° C)											
JAN	18.5600	19.4	1998	17.0	2011	0.5481	2.95	1.609	0.181	0.0181	0.214
FEB	18.0833	21.1	2004	15.6	2011	0.9048	5.00	1.311	0.247	0.0247	0.251
MAR	22.4300	172.0	1991	15.3	1982	28.2652	126.02	-0.603	-3.636	-0.3636	-0.002
APR	14.0200	18.5	2004	12.0	2008	1.3984	9.97	-0.215	-0.065	-0.0065	-0.131
MAY	10.2700	15.2	2004	7.9	2011	1.5306	14.90	-0.058	-0.019	-0.0019	-0.062
JUN	7.7267	14.2	2004	4.8	1987	1.6099	20.84	2.042	0.659	0.0659	0.205
JUL	6.8900	8.9	2002	4.0	2011	1.0623	15.42	0.202	0.046	0.0046	-0.011
AUG	9.1833	12.9	2002	5.8	2011	1.3157	14.33	0.204	0.058	0.0058	0.011
SEP	13.5700	16.3	1987	9.8	2011	1.2143	8.95	-1.794	-0.443	-0.0443	-0.149
OCT	17.3300	19.0	1987	14.3	2011	0.9692	5.59	-1.189	-0.241	-0.0241	-0.090
NOV	18.5433	19.7	2005	16.4	2011	0.8312	4.48	-0.156	-0.028	-0.0028	-0.021
DEC	18.6767	19.9	2002	16.8	2010	0.7219	3.87	0.318	0.049	0.0049	0.136

Rainfall (mm)

JAN	200.9333	368.6	1990	61.0	1992	84.3823	42.00	0.274	4.951	0.4951	0.062
FEB	148.7733	315.7	1989	33.4	1992	74.4166	50.02	0.275	4.380	0.4380	0.030
MAR	90.6233	410.5	2003	6.1	1998	75.5207	83.33	0.833	13.339	1.3339	0.076
APR	14.9833	84.9	1986	0.0	1987	21.6889	144.75	0.407	-1.891	-0.1891	-0.209
MAY	2.7967	29.6	1987	0.0	1982	60.1748	277.37	0.282	0.470	0.0470	-0.614
JUN	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
JULY	0.1067	3.2	1993	0.0	1982	0.5842	547.72	-0.398	-0.050	-0.0050	-0.949
AUG	0.0300	0.9	1999	0.0	1982	0.1643	547.72	0.248	0.010	0.0010	-0.922
SEP	1.1900	9.9	1982	0.0	1983	2.8889	242.76	-0.258	-0.160	-0.0160	-0.697
OCT	24.2267	166.3	2008	0.0	1990	37.9410	156.61	0.235	1.908	0.1908	-0.062
NOV	82.1467	258.3	2008	4.7	1987	59.0553	71.89	2.459	28.273	2.82735	0.297
DEC	168.9867	396.6	2007	55.9	2002	76.6348	45.35	0.699	11.397	1.1397	-0.016

Table 5: Temperature and Rainfall Data for Mt Makulu Station

Months	Arithmetic Mean	Highest Value	Year	Lowest Value	Year	Standard deviation	Covariance	TL@95%	Decadal changes	Magnitude of change	Mann Kendall
Maximum Temperature (° C)											
JAN	27.7200	29.2	1983	26.1	1986	0.8219	2.96	0.207	0.036	0.0036	-0.021
FEB	27.9633	31.3	1992	26.2	1997	1.1494	4.11	0.591	0.145	0.0145	0.076
MAR	28.9633	30.4	2005	25.9	2009	1.5176	4.36	-0.762	-0.200	-0.0200	-0.136
APR	27.7367	30.4	2005	25.9	2009	1.2139	4.38	-0.305	-0.079	-0.0079	-0.039
MAY	26.4933	29.0	1987	24.8	2004	1.1145	4.21	0.263	0.063	0.0063	0.034
JUN	24.6733	26.5	2006	22.8	1986	0.9347	3.79	0.707	0.141	0.0141	0.025
JUL	24.2833	27.8	2002	22.3	2009	1.0547	4.34	-0.767	-0.172	-0.0172	-0.182
AUG	26.9333	29.0	2004	24.7	2000	1.0453	3.88	1.208	0.264	0.0264	0.264
SEP	30.6267	32.0	1987	28.1	1982	0.8956	2.92	1.467	0.272	0.0272	0.117
OCT	32.1067	34.3	2010	29.7	1982	1.2213	3.80	2.616	0.615	0.0615	0.287
NOV	31.0267	33.1	1987	28.8	1996	1.0824	3.49	0.733	0.169	0.0169	0.057

DEC	28.2700	29.9	2011	26.2	2007	0.9014	3.19	0.289	0.056	0.0056	-0.025

Minimum Temperature (° C)

JAN	17.4933	18.8	1998	16.0	1992	0.5546	13.17	2.381	0.259	0.0259	0.241
FEB	17.0800	18.2	2001	15.7	2011	0.6995	4.10	2.153	0.299	0.0299	0.223
MAR	16.6967	18.3	1998	14.5	1994	0.8066	4.83	1.558	0.259	0.0259	-0.131
APR	14.7833	16.1	1998	12.6	1991	0.9656	6.53	-0.222	-0.046	-0.0046	-0.034
MAY	11.4400	13.6	1987	9.0	2004	1.1171	9.77	-0.968	-0.228	-0.0228	-0.094
JUN	9.1167	11.0	2000	6.9	1987	1.1709	12.84	-0.416	-0.104	-0.0104	-0.067
JUL	9.0900	11.5	2002	7.5	2011	0.8806	9.69	-0.649	-0.176	-0.00176	-0.085
AUG	11.7600	14.3	1995	9.0	2010	1.2716	10.81	-0.395	-0.075	-0.0075	-0.030
SEP	15.4067	17.77	1987	9.7	2006	1.3046	8.47	-1.194	-0.326	-0.0326	-0.145
OCT	18.0600	19.7	1995	16.6	1994	0.8274	4.58	1.289	0.222	0.0222	0.163
NOV	18.3467	20.0	1987	16.9	1985	0.7272	3.96	0.094	0.015	0.0015	-0.025
DEC	17.7500	18.5	2006	16.0	1986	0.4629	2.61	0.388	0.038	0.0038	-0.131

Rainfall (mm)

JAN	224.4500	376.6	1989	67.0	1995	80.6353	35.93	-0.070	-1.218	-0.1218	-0.021
FEB	172.3333	559.3	1989	37.3	2002	105.5074	61.22	-0.881	-19.685	-1.9685	-0.108
MAR	93.3033	274.8	2003	0.0	2009	67.4390	72.28	-0.113	-1.638	-0.1638	-0.071
APR	22.3100	146.1	1986	0.0	1987	35.5522	159.36	-0.523	-3.975	-0.3975	-0.080
MAY	3.1233	33.6	1996	0.0	1983	8.4087	269.22	0.769	1.374	0.1374	-0.614
JUN	0.0633	1.9	1983	0.0	1982	0.3469	547.72	-1.601	-0.114	-0.0114	-0.995
JUL	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
AUG	0.0	0.0	1982	0.0	1982	0.0	0.0	0.0	0.0	0.0	-1.000
SEP	0.4233	3.9	1987	0.0	1982	1.0836	255.98	-1.134	-0.258	-0.0258	-0.770
OCT	25.4500	164.5	1986	0.0	1996	36.0671	141.72	-0.408	-3.151	-0.3151	-0.3151
NOV	98.8467	284.3	2008	14.0	1988	62.3825	63.11	2.207	27.277	2.7277	0.200
DEC	195.0533	423.5	2007	63.7	1991	80.6202	41.33	1.355	22.711	2.2711	0.168

Table 6: Trend Values (z-statistic) for Monthly Rainfall for the Five Meteorological Stations

Meteorological Stations	Months											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lusaka City												
z-statistic	0.107	0.143	**1.98**	-1.534	-0.464	0.107	-0.285	-0.25	-0.928	**-1.998**	**2.248**	0.714
Kafue Polder												
z-statistic	-0.036	0.071	**2.07**	0.749	-0.446	0	0	0.071	-0.464	-1.427	0.642	0.589
Mumbwa												
z-statistic	0.054	**-2.105**	-0.981	**-1.748**	-0.785	0	0	0	-0.161	**-2.212**	1.178	0.571
Magoye												
z-statistic	0.464	0.214	0.571	-0.607	0.571	0	-0.107	0.071	-0.41	-0.624	**2.319**	-0.107
Mt Makulu												
z-statistic	-0.143	-0.821	-0.535	-0.089	-0.999	-0.464	0	0	-0.589	-1.106	1.356	1.285

NB: Bold values show statistically significant trends (at a < 0.05 and a < 0.1) with increasing and decreasing trends.

Table 7: Trend Values (z-statistic) for Monthly Maximum Temperatures for the Five Meteorological Stations

Meteorological Stations	Months											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lusaka City												
Z-statistic	0.071	1.249	0.036	0	0.946	1.231	-0.535	**2.212**	1.213	**1.927**	0.91	-0.161
Kafue Polder												
Z-statistic	-0.285	1.392	-0.731	0	0.161	0.571	-1.267	0.143	-0.928	**1.927**	0.285	-0.339
Mumbwa												
Z-statistic	-0.196	1.053	0.5	-0.143	1.088	1.267	0.054	1.409	0.892	**2.944**	0.517	0.624
Magoye												
Z-statistic	0	1.142	-0.268	-0.161	0.178	0.66	-0.196	**1.998**	0.196	**2.23**	0.517	0.071
Mt Makulu												
Z-statistic	0.143	0.803	-0.839	-0.161	0.428	0.446	-0.91	1.463	1.195	**2.426**	0.66	0.089

NB: Bold values show statistically significant trends (at a < 0.10, a < 0.01 and a < 0.05) with increasing trends.

Table 8: Trend Values (z-statistic) for Monthly Minimum Temperatures for the Five Meteorological Stations

Meteorological Stations	**Months**											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Lusaka City												
Z-statistic	0.696	0.589	0.821	-0.357	-0.999	0.821	-0.731	1.302	-0.054	**1.998**	0.268	-0.428
Kafue Polder												
Z-statistic	-0.036	1.267	-0.357	-1.088	-1.427	**-1.963**	-0.178	0.107	**-2.819**	**-2.391**	**-1.784**	-0.981
Mumbwa												
Z-statistic	-0.535	1.606	1.106	0.393	0.928	**2.177**	0.767	1.088	-0.678	1.392	-0.285	0.464
Magoye												
Z-statistic	**2.284**	**2.23**	0.321	-0.749	-0.303	**1.873**	0.178	0.624	-0.767	-0.393	0.428	1.641
Mt Makulu												
Z-statistic	**2.212**	**2.177**	1.302	0	-0.535	-0.161	0.054	-0.535	-0.892	1.481	0	-0.089

NB: Bold values show statistically significant trends (at a < 0.10, a < 0.01 and a < 0.05) with increasing and decreasing trends.

NB: for appendix VII – IX, see attached excel spreadsheets

APPENDIX VII: Excel Sheet showing Monthly, Seasonal and Annual Rainfall Data for the five Meteorological Stations.
DISSERTATION EXCEL SHEETS\Monthly, Seasonal and Annual Rainfall Data for All Meteorological Stations.xlsx

APPENDIX VIII: Excel sheet showing monthly, seasonal and Annual Maximum Temperature Data for the five Meteorological Stations.
DISSERTATION EXCEL SHEETS\Monthly, Seasonal and Annual Maximum Temperature Data for all the Meteorological Stations.xlsx

APPENDIX IX: Excel sheet showing monthly, seasonal and Annual Minimum Temperature Data for the five Meteorological Stations.
DISSERTATION EXCEL SHEETS\Monthly, Seasonal and Annual Minimum Temperature Data for all the Meteorological Stations.xlsx