EXPLORING TECHNOLOGICAL CONDITIONS FOR THE ADAPTIVE CAPACITY OF HYDROPOWER ORGANISATION TO THE IMPACTS OF CLIMATE CHANGE: A CASE STUDY OF ZESCO IN THE KAFUE RIVER BASIN, ZAMBIA

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DECLARATION

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DEDICATION

This thesis is dedicated to the Siame family and to the memory of my late father Saxon Nyela Siame, who believed that indeed I can achieve greater things.

ABSTRACT

Hydropower organisations in various river basins are coming under immense stress as drought caused through climate change continues to pose serious threats to water security, consequently reducing hydropower generation. Evidence shows that technology as a major component of adaptive capacity is proving limited in its response to drought, thereby contributing to power shortages. In the past few decades, the hydro technology of the Zambia Electricity Supply Corporation has remained stagnant with regard to type, capacity and location and its entirely hydro-based technology, making it sensitive to climate change events such as low rainfall. Technological adaptation can thus be a key determinant in creating prerequisites for enhancing the adaptive capacity of hydropower organisations to cope with drought and mitigate against energy crises.

This thesis examines the technological adaptive capacity of hydropower organisation to cope with the effects of climate change, particularly drought. It accomplishes this by ascertaining the technological prerequisites of adaptive capacity using the case of ZESCO in the Kafue River basin in Zambia. Therefore, the main objective of this study was to ascertain the role of technology in influencing the prerequisites of adaptive capacity to drought. This involved exploring three technology dimensions: technological diversity, technology capacity and technology location as a basis from which to understand adaptive capacity. As a specific objective, the study particularly examines how each dimension of technology is a factor in creating conditions necessary for enhancing adaptive capacity to cope with drought.

Methodologically, the thesis applies a field research method in its case study approach, and is qualitative in nature in order to assess adaptive capacity. The study uses in-depth interviews and documentary analyses to gain insights and understanding of how technology influences the prerequisites of adaptive capacity to cope with drought associated climate change. The in-depth interviews involved four key interviews with relevant managers at ZESCO, while documentary analysis comprised of a range of both published and unpublished documents.

The study revealed that ZESCO is faced with limited technology in terms of location, capacity and diversity thereby, contributing to low power generation and consequently leading to power shortages (load-shedding). Thus, technology adaptation is vital in creating prerequisites for enhancing adaptive capacity to cope with drought-associated climate change in three ways: diversification of power plants, expanding the capacity of power plants, and varying the location of power plants. The extent of technology can play a vital role in influencing the prerequisites for enhancing adaptive capacity through increasing the technology by constructing new power plants and expanding the existing ones. Technology diversification (solar, wind and thermal technologies) play a vital role in creating the necessary conditions to promote adaptive capacity by reducing vulnerability to drought and increasing access to a wide range of technologies. Location of technologies is also important in creating the prerequisites of adaptive capacity by constructing the new power plants in various localities, especially those which are less prone to drought than the Kafue River Basin. In addition, technology diversification and location can promote water security in the basin.

Key Words: Hydropower, Climate Change, Drought, Technology, Adaptive Capacity, Water Security, Location, Size, Diversification.

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ABBREVIATIONS AND ACRONYMS

AGW	Anthropogenic Global Warming
ASL	Above Sea Level
CRB	Congo River Basin
ENSO	El Nino Southern Oscillation
EPA	Environmental Protection Agency
ERB	Energy Regulation Board
EWD	Energy and Water Development
GDP	Gross Domestic Product
GIS	Geographical Information Systems
GRZ	Government of the Republic of Zambia
HPP	Hydropower Plant(s)
IAPRI	Indaba Agricultural Policy Research Institute
IDC	Industrial Development Corporation
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Partnership (s)
ITTPP	Itezhi-Tezhi Power Plant
IWM	Integrated Water Management
IWRM	Integrated Water Resources Management
KGUPP	Kafue Gorge Upper Power Plant
KRB	Kafue River Basin
LRB	Luapula River Basin
MASL	Metres Above Sea Level

MEWD	Ministry of Energy and Water Development
MMEWD	Ministry of Mines, Energy and Water Development
MW	Megawatts
MoU	Memorandum of Understanding
ODI	Overseas Development Institute
NEP	National Energy Policy
RECP	Renewable Energy Corporation Programme
RFP	Request for Proposal
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SES	Social Ecological Systems
SSA	Sub-Saharan Africa
WRI	World Resources Institute
WWF	World Wide Fund
WFP	World Food Programme
UNFCCC	United Nations Framework Convention on Climate Change
ZDA	Zambia Development Agency
ZESCO	Zambia Electricity Supply Company
ZIPAR	Zambia Institute for Policy Analysis and Research
ZNBC	Zambia National Broadcasting Cooperation
ZRA	Zambezi River Authority
ZRB	Zambezi River Basin

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1 CHAPTER ONE - STUDY BACKGROUND

1.1 INTRODUCTION

This thesis examines the adaptive capacity of hydropower organisations to cope with the impacts of climate change. Using the case of the Zambia Electricity Supply Company (ZESCO) in the Kafue River Basin (KRB), the thesis probes the essential prerequisites for adaptive capacity, particularly through the dimensions of technology, which include diversification, capacity and location. There is a common view throughout the world that the impacts of climate change (such as drought) are negatively affecting water resources in a way that is detrimental to water security. As a result, water users, including ZESCO as a hydropower organisation in the Kafue River Basin, are facing enormous challenges of water security as they depend entirely on the function of water resources. Frequent droughts are affecting the water levels of rivers and dams and negatively impacting the capacity to generate hydropower, consequently contributing to power shortages and outages (commonly known as load-shedding). To better understand the prerequisites for adaptive capacity in the context of hydropower organisations and the prevailing impacts of climate change, it is important to investigate the available technologies (both hydro and non-hydro power plants) that necessitate adaptive capacity. Determining the conditions for adaptive capacity from the perspective of technology not only helps hydropower organisations to increase their adaptive capacity, but can also help to promote necessary mechanisms required for achieving water security in the Kafue River Basin.

This chapter provides the contextual basis of the study. The first section provides the research background to the study. The second section frames the problem statement on which the study is premised. The third section provides the intended purpose and significance of the study and its objectives. Finally, the structure of the thesis is provided in the last section of the chapter.

1.2 RESEARCH BACKGROUND

Climate change is a reality and the extreme events associated with it are increasingly evident (Kabat et al., 2003; Intergovernmental Panel on Climate Change, First Assessment Report (IPCC FAR), 2007; Alavian, 2009). The majority of water users, especially hydropower organisations, are interested in understanding how to manage climate change impacts through enhancing adaptive capacity (IPCC, 2007). Contemporary studies for example, have shown that the levels of warming considered to be safety thresholds may, in some cases, be crossed by 2030 in several regions throughout the world, hence the tremendous need to pursue adaptive capacity for drought (Huntjens et al., 2010; Schipper, 2011; Kalaugher et al., 2012). Climate change is expected to impose significant negative effects on precipitation patterns, and extreme events such as drought will continue to impact on water resources. This will thus intensify implications for water users such as hydropower organisations, which are expected to safeguard water resources (Engle & Lemos, 2010).

One of the impacts of climate change manifests through water resources in river basins. These impacts include extreme drought, flooding, rising temperatures, and the modification of aquatic systems among others (Hofmann, et al., 2011). Moreover, water is already a key risk for many social ecological systems (SES) such as hydropower organisations which are complex, and are further compounded by climate change risks and uncertainties (Ostrom, 2010). At present, as climate change is affecting water security mainly through extreme drought, the adaptive capacity of many water users such as hydropower organisations seems weak (Alavian et al., 2009). Evidence suggests that many hydropower water user organisations do not have the capacity to appropriately cope with the effects of climate change, as can be seen from the prevailing occurrence of severe power shortages in the Southern African region. Yet, few assessment studies have been done to understand the association between drought and these prevailing shortages.

Moreover, evidence of low water levels has become prominent not only in the Kafue River Basin but also in other major river basins where hydropower plants are situated (ZESCO, 2011). Similar scenarios are also observed in other neighbouring countries in Southern Africa including Zimbabwe, South Africa, Botswana, and Namibia. As such, extreme drought is advancing water scarcity and thereby threatening water security, which in turn contributes to low power generation that leads to power outages. Nevertheless, as hydropower organisations are expected to respond to such climate change associated shocks, there is a need for hydropower organisation to develop adaptive capacity to cope with drought. Generally, the failure of hydropower organisations to be adaptable is indicative of problems of limited technology (ZESCO, 2012). In this regard, the role of technology in determining adaptive capacity of hydropower organisations is still blurred, particularly in the context of diversity, capacity and location of various types of technology.

Over time, the water resources of Southern Africa have deteriorated due to the effects of climate change, thereby presenting various water challenges of different dimensions (Hamududu & Killingtveit, 2016; Mpanga et al., 2016; Indaba Agricultural Policy Research Institute (IAPRI), 2016). This position has created among other things, competition and tension amid various water users (Nkhata, 2014). Despite the fact that water shortages have become common in many river basins, pressure is mounting on numerous water users, including hydropower organisations, to effectively respond to frequent droughts. Climate change presents extensive problems for water security at river basin level (Alavian, 2009). According to Mpanga et al. (2016), in recent years the generation of electrical energy has been severely affected by low rainfall. Therefore, water in river systems demands to be managed in a way that responds with sensitivity to the changing climate and the exposure to risks and uncertainties over time. In so doing, water users need to develop adaptive capacity in order to counteract the threats posed by climate change impacts, particularly drought.

It is evident that the effects of climate change such as extreme drought are manifesting through water resources in river basins. Hydropower organisations are negatively impacted due to lack of technological ability to adapt, which not only affects water security but also hydropower generation, leading to power shortages (Alavian, 2009: Engle & Lemos, 2010; Lawford, 2011; (Honkonen, 2016). Hydropower organisations are suffering from these impacts of climate change such as drought (IPCC, 2007). For example, ZESCO, a hydropower organisation and major water user in the Kafue River Basin, has been affected by drought through lowering the generation capacity of hydropower resulting in power shortages. As such, drought is contributing to the low generation of hydropower and to increase power shortages (Mpanga et al., 2016).

The technological entropy of climate change propagates numerous implications for hydropower organisations (Hofmann, et al 2011). Evidence of the low adaptive capacity of hydropower organisations in responding to drought is apparent in Zambia, as witnessed through inadequate power generation and severe power outages (ZESCO, 2011). The reduced generation of hydropower being experienced is resulting in power outages (load shedding) certainly due to limited technology and adaptive capacity. Media reports indicate that during drought episodes, hydropower organisations are failing to produce adequate hydropower which is resulting into massive power shortages. As a consequence, it is causing the eventual failure of hydropower organisation to respond to drought. Therefore, these predominating events suggest evidence of characteristics of low adaptive capacity of hydropower organisations to cope with drought and suggestive of lack of technology. This evidence is supported by several other studies suggesting that adaptive capacity to drought is low in developing countries (see for example Honkonen, 2016; Overseas Development Institute (ODI), 2010; Brooks et al., 2005; Pelling & High, 2005).

1.3 PROBLEM STATEMENT

There has been limited research on exploring the effects of climate change on water user organisations (Boyd & Folke, 2012). Although it is well affirmed that the adaptive capacity of hydropower organisations might not be sufficient (ODI 2010), the fundamental reasons why power shortages have persistently prevailed is not well understood from the technological aspect of adaptive capacity in Southern Africa. Thus this poses a further threat to power generation while increasing the risk for water security at river basin level. The implications are that planning for adaptation and water security in the event of major climate change shocks would be difficult. Additionally, there is limited research regarding the adaptive capacity of hydropower water users at the river basin level. A number of adaptive capacity studies have frequently focused on aggregate assessments at the national and regional levels that are too broad for water security contextualisation (Brooks et al., 2005; Ford et al., 2006). As such, more research is needed to uncover specific variables and attributes of the adaptive capacity of hydropower water users.

This study was motivated by the need to understand the relationship between the adaptive capacity of the hydropower water user organisations' drought and water security by using the technology component of adaptive capacity. This was premised on the understanding that there is a need to assess adaptive capacity in the context of technology to help enhance the adaptive capacity of water to drought, which in turn will enhance water security, particularly at river basin level. The role of technology in enhancing adaptive capacity to climate change impacts such as drought is now considered an emergent property of hydropower organisations, particularly in the context of water security (Walker et al., 2004; Engle, 2007). It is important to bear in mind that this study was not designed to look at the actual processes of climate change, but rather the intention was to assess and document the available technological conditions necessary for enhancing adaptive capacity of hydropower organisations in coping with drought. Hence, the study is based on the three dimensions of technology (diversification of technology, generation capacity and the location of technology) in order to understand the prerequisites of adaptive capacity.

This study will contribute to advancing the understanding of adaptive capacity pertaining to water security at river basin level, particularly in the context of how the technologies of hydropower organisations can be used in responding to the prevailing impacts of climate change, and mitigating against the threats it poses to hydropower. It underscores the prerequisites or conditions required for pursuing the adaptive capacity of hydropower organisations. While the study focuses on the three main dimensions of technology: diversification, capacity and location, it exemplifies how these dimensions can help to promote water security in the river basin. From this perspective, water security denotes the capacity of social actors to safeguard access to the desirable quantity and quality of water resources for hydropower organisations and ecosystems. "Safeguard" implies the capacity to manage social risks linked with the quantity and quality of water (Alavian, 2009; Nkhata et al., 2014). It is important to note that creating the necessary conditions to increase adaptive capacity is instrumental in enhancing water security.

1.4 RESEARCH AIM

The main aim of this study was to explore the adaptive capacity of hydropower organisations to cope with the effects of climate change. To accomplish this, the study sought to ascertain the technological prerequisites for adaptive capacity using the case of ZESCO in the Kafue River Basin as an example.

1.5 RESEARCH QUESTIONS

1.5.1 MAIN RESEARCH QUESTION

To assess how technology can create the prerequisites for enhancing adaptive capacity to cope with drought.

1.5.2 SPECIFIC RESEARCH QUESTIONS

- What is the role of technology diversification in creating prerequisites for adaptive capacity to cope with drought?
- What is the role of generation capacity in creating prerequisites for adaptive capacity to cope with drought?
- What is the role of location of technology in creating prerequisites for adaptive capacity to cope with drought?
- Why has it taken so long for ZESCO to respond to or cope with drought?

1.6 STRUCTURE OF THE THESIS

This thesis is structured in six chapters. Chapter one sets out the introduction and the background of the study in brief, together with the problem statement of the research, significance of the study and research questions. Chapter Two provides a relevant literature review elucidating and explaining theories of climate change, and the adaptation and adaptive capacity which form the backbone of the theoretical framework, and informs the analytical section. Chapter Three presents the case study area and the study methodology that helped to elucidate the procedures and approaches used in order to understand the phenomenon under study. Through this, the type of field research and case study approach are explained. Chapter Four presents the findings from the assessment by providing all the evidence and responses regarding interviews and documents. Thereafter, the results of the study are further discussed in Chapter Five, which provides interpretation and the meaning of the results. Finally, Chapter Six presents the conclusion and final recommendations.

2 CHAPTER TWO - LITERATURE REVIEW

2.1 INTRODUCTION

The main goal of this chapter is to provide the relevant literature reviewed in the study (Babbie, 2013). The chapter chiefly put emphasis on the theories and concepts which underpin this study. Firstly, theories of climate change are examined within the realm of social-ecological systems, particularly hydropower organisations. Thereafter, the available literature on water resource management and water security and the impacts of climate change is provided. An account of adaptive capacity and adaptations to climate change and how they relate to each other is given. Concepts of adaptive capacity and its determinants are also explained, with particular emphasis given to its proponent authors who have explored and assessed it. The complementary concepts of resilience and vulnerability have also been highlighted, as they are related to adaptive capacity. At the end of this chapter, the existing literature on water user organisations is provided, particularly hydropower organisations in the context of drought at the study site. The literature review section presents both the theoretical background and conceptual background of the study.

2.2 UNDERSTANDING CLIMATE CHANGE IN A SOCIAL-ECOLOGICAL SYSTEM

Over the past century, increasing human activities on biophysical processes have caused many environmental problems (Bast, 2012). Expanding our understanding of the underlying biophysical processes before making decisions has been a typical response to climate change. However, it is now acknowledged that understanding of such processes requires a complete understanding of SES, with emphasis on interconnections between social and ecological systems (Anderies et al., 2004). Such an inquiry comprises learning how SESs, such as hydropower organisations, function and how they are modified (Ostrom, 2005). Climate change is undermining water security and is likely to increase the risk of SES malfunction.

In this study, climate change is defined in line with the IPCC (2007). Climate change implies a change in the state of the climate that can be identified by variability of its properties, and which persists for an extended period, usually decades or longer (IPCC, 2007). The IPCC FAR (2007) asserts that climate change is already happening throughout the globe, and is mainly affecting water resources and humans. Climate change is highly impacting on fresh water and has massive implications for SES. Moreover, climate change is projected to vary rainfall patterns to undesirable amounts in the future. The perceptions that humans are responsible for these inexorable changes in the climate is gaining widespread acceptance and popularity around the globe (Lawford, 2011; Grafton & Hussey, 2011). According to IPCC FAR (2007), many modelling studies show that climate change is likely to increase the occurrence of extreme weather events (for example, floods and drought). For instance, Kharin et al. (2007) pointed out that precipitation events may be reduced in the near future if not now, with many regions of extreme rain experiencing more intense rainfall, while regions with dry conditions continue to experience more water stress.

2.2.1 ANTHROPOGENIC GLOBAL WARMING THEORY

A familiar theory of climate change is called anthropogenic (man-made) global warming (AGW) (Bast, 2010). It holds that man-made greenhouse gases such as carbon dioxide (CO_2), methane, and nitrous oxide, were the predominant causes of the global warming that has occurred during the past 50 years, which caused climate change. It also contends that human emissions of greenhouse gases are causing catastrophic rises in global temperatures, resulting to climate change and variability (Green & Armstrong, 2007; Bast, 2010). Evidence of human activities in the previous century such as deforestation and burning wood and fossil fuels, increased the concentration of greenhouse gases in the atmosphere by approximately 50%, and this is likely to double in the next decade (Gore, 2006). This will have a direct impact on water security, water users and especially hydropower. Proponents of the AGW theory believe man-made greenhouse gases are responsible for climate change which manifests through extreme drought, floods, temperature, species extinction, and many other catastrophes. Hence, the adaptive capacities of SES are required to cope with such threats (IPCC, 2007).

2.2.2 HUMAN FORCING THEORY

Another theory of climate change is the human forcing theory, which holds that transformation of the Earth's surface by deforestation and urbanisation is prominent in increasing climate change (Bast, 2010). Removing trees by burning releases greenhouse gases into the atmosphere, and cutting them down prevents forests from storing carbon. Crop lands and urban development replace the forests. The IPCC (2007) has estimated that between one-quarter and one-third of anthropogenic carbon dioxide emissions are due to deforestation, causing climate variations and impacts on water resources in river basins. Authors of many contemporary books on climate change, include Robert Balling, Fred Singer, Christopher Essex, Patrick Michaels, and Roy Spencer among others. They describe the AGW theory and point to other, more probable theories such as planetary motion, ocean currents and others. Water and hydro-energy are among the key sectors that are mostly likely to be directly affected by the induced impacts of climate change. Therefore, adaptation is currently a key component in the pursuit of opportunities to minimise the losses caused by climate change (Adapts Project, 2009).

2.2.3 EL NINO SOUTHERN OSCILLATION

Presently, the El Nino Southern Oscillation (ENSO) theory have been derived. According to Lawford, (2011), climate patterns are frequently linked with regional anomalies in the global water cycle. The ENSO patterns arising along the equator within the western Pacific (La Niña) or within the eastern Pacific (El Niño) have been described as the most serious cause of seasonal atmospheric forcing that is contributing to climate variability and eventually causes climate change (Trenberth & Hoar, 1997; Grafton & Hussey, 2011; Lawford, 2011). Changes in temperature on the surface of the sea cause an oscillation in pressure between the Pacific and Indian Oceans. ENSO events result in droughts over a wide landscape, due to high pressure. Although studies of the processes of ENSO are blurred, it is believed to be a key contributing factor to climate variability and climate change in the southern hemisphere, particularly in Southern Africa (Huffman 2010).

Therefore, climate change is anticipated to cause negative consequences for water security in river basins. Honkonen (2016) suggests that today, climate change is the most persistent challenge faced by people and the environment, while risks and uncertainties will continue to be extreme, including increased global temperatures, sea level rises, extreme precipitation events, and risks and disturbances to social ecological systems. In addition, impacts of climate change will mostly occur in regions and decreases the available fresh water (Lawford, 2011).

2.3 WATER RESOURCES MANAGEMENT

According to Grafton and Hussey (2011), the importance of water cannot be overstated, as it is essential in maintaining life on Earth. In fact, life could be depleted without water (Thapliyal, 2011). Water strongly impacts productivity of various economic sectors including agriculture, mining and energy production. Water management throughout the world faces a common challenge of how to allocate fresh water resources in a fair, efficient and sustainable fashion while being environmentally sound, socially appropriate and economically viable. (Andreen, 2006). For example, climate change associated drought has constrained water governance structures in coping with present and future challenges (Pahl-Wostl 2009). In recent years, most policies devised to achieve the equitable distribution of water have disregarded non-consumptive use, which has not been properly understood until recently. Many policy regimes have ignored its environmental use because water was considered a commodity for human consumption (Andreen, 2006; Grafton & Hussey, 2011). For a long time, water resource managers have managed water resources in a relentless fashion, with little interest committed to adverse environmental impacts (Andreen, 2006). Furthermore, while the bias towards human consumption and economic development over the environment is strongly advancing, climate change is reducing the availability of fresh water resources (Grafton & Hussey, 2011).

Presently, water related conflicts suggest poor management of water resources. Thapliyal (2011) mentions that climate change results into droughts and threatens water security. In fact, the situation will get worse in the future until there is change in how water is managed. Unless there is shift in the manner in which water is managed, problems of water scarcity will persist, as climate change is expected to increase the severity of droughts in the future (IPCC, 2007; Grafton and Hussey, 2011).

Therefore, water resources management provides a basis to both understand and help overcome water security challenges. To minimise such challenges, people must deal with issues of water overuse and misuse. Contributing to this fact, enhancing adaptive capacity can play a pivotal role in dealing with the impacts of climate change (Grafton & Hussey, 2011). As climate change threats are increasingly persistent, water users and managers must find approaches to sound water management (Grafton & Hussey, 2011; Lawford, 2011). In previous decades, evidence has shown that water resources planning and management was purely the responsibility of hydrologists and engineers. Presently, the emphasis is shifting to solutions that can achieve affirmative outcomes to society, environment and the economy. There must be integrated engagement of a wide range of geographers, ecologists, historians, hydrologists, political scientists, environmental engineers, economists, anthropologists, sociologists, lawyers and others (Lawford, 2011). However, achieving stability in water resources is not an easy endeavour (Andreen, 2006; Gerlak & Mukhtarov, 2015).

2.4 WATER SECURITY

Water security gained popularity in previous decades to become a new concept of water community (Bakker 2012; Cook & Bakker, 2012; Lautze & Manthrithilake, 2012; Gerlak & Mukhtarov, 2015). Water security has widely received scholarly writings and policy-making after becoming a renowned concept at the World Water Forum in 2000, and at the Water Security, Risk and Society Conference in 2012, and the Stockholm World Water Week of 2013 (Gerlak & Mukhtarov, 2015; Mukhtarov & Cherp, 2015; Honkonen, 2016). Research on water security penetrated the security purview by incorporating non-military threats affecting people such as societal, economic, political and environmental concerns. In the 1990s, water security became connected to human security in terms of economic security, food security, environmental security and military security (Thapliyal, 2011; Cook & Bakker 2012). Therefore, water security was regarded as a condition of adequate quantity and quality of water for achieving various societal and environmental needs (Gerlak & Mukhtarov, 2015).

2.4.1 THE FRAMING OF THE WATER SECURITY CONCEPT

The literature on water security reveals a variety of framings. However, the meaning of the concept is distinctively based on context, audience and discipline (Tarlock & Wouters, 2009; Wouters, 2010; Gerlak & Mukhtarov, 2015; Mukhtarov & Cherp 2015). In this study, the concept of water security is adopted from UN-Water (2013) which refers to:

> *...the ability of a population to safeguard sustainable access to adequate quantities of appropriate quality water for supporting livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability.*

Water security requires fair, efficient and transparent allocation of water among users. It must fulfil people's needs, be reachable and affordable to all, and must be collected and treated correctly (Gerlak & Mukhtarov, 2015; Honkonen, 2016). Water security definitions have the commonality of being multi-dimensional. The right of humans is the main connection to water security, with the aim of preventing conflicts while accepting a reasonable degree of water-associated risks and emphasising protection of water-dependent ecosystems (Grafton & Hussey, 2011; Honkonen, 2016). Therefore, water security is mostly regarded as progression of sustainable development focusing on the quantity and quality of available water resources in river basins for both societal and ecological necessities (Lankford et al. 2013). Moreover, following the Environmental Protection Agency (EPA) (2013), decision-makers significantly recognise water security patterning to water management. UN-Water (2013) affirms that water security is a critical component of human security, and that addressing it is vital for governance stability (Zeitoun, 2011; Galaitsi et al., 2015). Therefore, water security is characterised as an emerging concept that demands attention to the human and environmental dimensions of water resources management. Water security research is growing with the interest in climate change (FAO 2008). In addition, water security emphasises perspectives of water protection, its obligatory thresholds and levels of risk and uncertainty in planning. It signifies a discursive way of understanding water issues, as it requires attention to the management of water resources and the risks involved in water mismanagement practices (Bakker & Morinville 2013; Gerlak & Mukhtarov, 2015).

Water security also endeavours to challenge the older concept of Integrated Water Resource Management (IWRM), which dominated water management discourse in previous decades (Bakker & Morinville 2013; Gerlak & Mukhtarov, 2015). The shift from IWRM towards water security may not entirely transform and improve water governance on the ground, but rather face the same fate as IWRM until there is a change in how water problems are identified and understood, and policy solutions are designed (Gerlak & Mukhtarov, 2015). Many studies have shown that water security is important in managing water resources (see for example, Biswas & Seetharam, 2008; Tarlock & Wouters, 2009; Wouters, 2010; Zeitoun, 2011; Cook & Bakker, 2012; Lautze & Manthrithilake, 2012; Bakker & Morinville, 2013; Galaitsi et al., 2015; Mukhtarov & Cherp, 2015). Water security is complementary to a diverse range of issues, including climate change. The emerging literature and debates on water security follow the relationship of the concept with the IWRM discourse on all scales of management. Water security emphasises issues of climate change such as drought, floods, pollution, water quality and quantity, ethics and values (Gerlak & Mukhtarov, 2015).

2.5 RISKS OF CLIMATE CHANGE ON WATER SECURITY

It is important to note that despite the effects of climate change being problematic, change is constant in fresh water systems because fresh water resources are not stagnant. However, climate change associated risks significantly proliferate with the increasing concentration of greenhouse gases (McCaffrey, 2003; Honkenoni, 2016). As a result, in some cases, climate change is reducing water availability and undermining water security. Climate change is predicted to significantly decrease available surface water and groundwater resources in most dry regions and is likely to increase the frequency of droughts in regions that are presently dry (IPCC, 2007; Mpanga et al., 2016). Climate change is also affecting seasonal variability of water flows and groundwater levels. Therefore, adaptive capacity is required as it turns out to be the most steadfast ally of water security (Honkenoni, 2016).

Honkenoni (2016) argues that if the rate of change in the water cycle surpasses its capacity to adapt, water security in climate change affected river basins will evidently deteriorate. Generally, the impacts of climate change on fresh water resources are influenced by various factors such as geographical location, water demand and use, governance structure and institutions, management mechanisms, and the adaptive capacity and vulnerability of a particular environment. It is clear throughout the globe that impacts of climate change will not be on the same scale in many river basins, because impacts occur depending on location (Petersen-Perlman et al., 2012). Water security risks, like droughts, are likely to increase and become magnified by their related uncertainties. Climate change and other consequences of extreme water-related events exacerbate the problems undermining water security. This has caused water crises due to climate change across the world to be called government crises (Tir & Stinnett, 2012; Honkenoni, 2016).

2.6 ADAPTATIONS AND ADAPTIVE CAPACITY

The literature on climate change adaptation points to numerous key determinants for building adaptive capacity. Adaptive capacity is latent in nature in that it can only be measured after it has been realised (Brooks et al., 2005). Hence, prior to climate change impacts, adaptive capacity can be assessed based on assumptions about different factors that might facilitate or constrain certain responses (IPCC, 2001; Yohe & Tol, 2002; Adger, 2003; Brooks et al., 2005; Folke, 2011). Adaptability refers to the capability of actors to influence resilience. In the case of a SES, it amounts to the capacity to manage resilience (Walker et al., 2004). Resilience of ecosystems and SES was started by Holling, (1973). Since then, it has been discussed by many scholars including Adger (2001), Berkes et al. (2003), Anderies et al. (2004), Walker et al. (2004), Folke (2006), and Smit and Wandel (2006). Resilience is the capacity of a SES to absorb disturbance and reorganise while experiencing alteration, but still fundamentally hold the same function, structure, identity and feedbacks (Walker et al., 2004). Hence, adaptive capacity incorporates the resilience concept. Most authors have researched adaptive capacities at national levels for example Kelly and Adger, (2000); Ford and Smit, (2004). Many scholars of adaptation have focused on the impacts of climate change at community level adaptations, and impacts and prediction modelling (Adger, 2000; Adger, 2006; IPCC, 2007; Engle, 2010).

2.6.1 THE FRAMING OF ADAPTIVE CAPACITY CONCEPT TO CLIMATE CHANGE

Adaptive capacity has developed in the climate change scholarship and has been explored by various authors including Smit and Pilifosova (2003), Yohe et al. (2003), and Adger (2006). The concept of adaptive capacity is usually used in the broader context of vulnerability and resilience studies (Smit & Wandel, 2006). Adaptive capacity was originally used in biology to refer to the ability of a SES to adapt to a certain range of environmental shocks (Gallopín, 2006). It is worth mentioning that adaptive capacity in the context of climate change is a component of social-ecological systems. Therefore, in this study, adaptive capacity refers to the ability of the organisation (systems) to adjust, in order to adapt to the impacts of climate change (Adger, 2006). Consistent throughout the literature is the notion that the vulnerability of any system on any scale is a function of the exposure and sensitivity of that system to hazardous situations and the ability or resilience of the system to cope, adapt or recover from the effects of such conditions. Therefore, adaptation is a manifestation of adaptive capacity, and represents a means of reducing vulnerability. The greater the adaptive capacity of the organisation to a given climate event, the lower its vulnerability (Smit et al., 2000; Smit & Pilifosova, 2003). Furthermore, Brooks (2003), describes adaptation as adjustments in the characteristic behaviour of SES that enhance its ability to cope with external stress such as climate change impacts. However, the adaptive capacity of SES at river basin scale remains uncovered in many regions throughout the world, including the Southern Africa region (Smit et al., 2000).

In this study, adaptive capacity is defined as the ability or capacity of a system (organisation) to cope with existing and or anticipated change shocks (drought) (see for example, IPCC, 2001; Yohe & Tol, 2002; Adger et al., 2003; Brooks, 2003; Smit & Pilifosova, 2003; Gallopin, 2006). Adaptation refers to adjustments in a system's behaviour and characteristics that enhance its ability to cope with shocks (Smit & Pilifosova, 2003). These are actual mechanisms undertaken to respond to impacts of climate change. The IPCC (2007) also defines adaptive capacity as the ability or potential of a system to successfully respond to external impacts such as climate change. It includes adjustments in both behaviour and in resources and technologies. Adger et al. (2007) elucidates that adaptive capacity refers to changes in processes, practices, or structures to moderate or offset shocks. It involves adjustments to reduce the vulnerability of organisations to climate change. Adaptive capacity is an emergent property of SES (Cumming, 2011). It determines the extent of the system's capacity to undertake adjustments to cope with impacts in order to sustain and improve its function during climate change effects. Results in many studies have shown that the adaptive capacity of SES is essential to reducing vulnerability and increasing chances of survival when exposed to external perturbation (IPCC, 2001; Adger, 2006). Therefore, adaptive capacity studies are mostly coupled with vulnerability and resilience concepts.

Yohe and Tol (2002), Adger (2003), Smith et al. (2003), and Walker (2005), were also among the proponents who suggested operationalising the emerging concept of adaptive capacity and its determinants for the impacts of climate change such as drought. However, most suggestions from the findings were done at national scale paying very little attention to the river basin scale (Tol & Yohe, 2007). Determinants of adaptive capacity are dynamic and vary over time according to the type of stress, place and stimulus, and are system-specific (Smit & Wandel, 2006). Although scholarship regarding adaptive capacity of hydropower organisation in Southern Africa seems limited in the climate change field, there is a considerable desire to understand the conditions that influence the adaptive capacity of organisations to climate stimuli (Smit & Wandel, 2006; Honkonen, 2016).

Other studies have attempted to provide conceptual frameworks for indicators of adaptive capacity to climate change (see for example IPCC 2001; Eakin & Lemos 2006; Engle & Lemos, 2010). Adaptive capacity is an emergent property of socio-ecological systems (Pelling, 2011). The adaptive capacity of SES is usually assessed using a framework to analyse SES (Ostrom, 1990). In order to assess the adaptive capacity properly, the proposed framework allows for analysis of its three groups of determinants: system components, functions and interactions. Each category of determinants possesses dissimilar roles in the modelling of adaptive capacity. Drivers or determinants or indicators of adaptive capacity are prerequisites that influence organisations to enhance adaptive capacity to the effects of climate change (Smit et al., 2001; Walker et al., 2002; Adger, 2003; Engle & Lemos, 2010; Hinkel, 2011). Many authors have proposed adaptive capacity determinants which include: financial resources, knowledge and information, infrastructure and material resources, institutions and networks, technology and information resources, (see for example Smit et al., 2001; Yohe & Tol, 2002; Smit & Pilifosova, 2003; Adger, 2003; Pelling & High, 2005; Adger et al., 2007; IPCC, 2011). They argue that freshwater user groups or SES with limited economic resources, poor information and skills, low levels of technology, poor infrastructure and inequitable access to resources, have little capacity to adapt, thus they decrease water security in many river basins. For example, the research conducted in Brazil by Engle and Lemos (2010) unpacked and operationalised the determinants of adaptive capacity. They revealed that government institutions initiate greater adaptive capacity for water management systems which have remained resilient during climate change related episodes such as drought. The study helps to establish indicators that influence adaptive capacity of water users to climate change at river basin level. Additionally, there are other studies that focus on the adaptive capacity of countries, regions or communities, with comparative evaluations or ratings based on criteria, indices and variables (see for example Adger et al., 2004; Brooks et al., 2005).

Adaptations to climate change takes many forms (anticipatory, concurrent, and reactive), intent (autonomous, planned), spatial scope (local, widespread) and form (technological, behavioural, financial, institutional, and informational) (IPCC, 2001; Smit & Wandel, 2006). Anticipatory adaptation is proactive and proceeds before climate change effects occur. Reactive adaptation proceeds after impacts occur. And autonomous adaptation indicates spontaneous adjustments that are not deliberately initiated in response to climate change (Smit & Wandel, 2006; Boyd & Folke, 2012; Boyd, 2015). In addition, adaptive capacity is context-specific among water users, individuals, and over time. Attempting to assess adaptive capacity to climate change is not a straightforward task (Pelling, 2011).

2.7 ADAPTIVE CAPACITY AS A STRATEGY FOR CLIMATE CHANGE

Impacts of climate change are likely to pose huge implications for water security (IPCC, 2007). As a result, attention is increasingly put to adaptive capacity as a coping strategy (Alavian, et al. 2009). Many studies have explored the effects of climate change on water resources and how users respond either to adapt or to mitigate such effects (Hofmann et al., 2011). For instance, a recent study by Kalaugher et al. (2012) focused on adaptation strategies to climate change, while Conway and Schipper (2011) analysed climatic trends and variability to assist in understanding climatic changes. Cai et al. (2011) focused on integrated modelling approaches for climate change impact and adaptive capacity planning. Other studies, which attempted to address impacts of climate change and adaptation in Zambia, include those of Yamba (2011); Wamulume et al. (2011); Muzeya, (2014); IAPRI, (2015), and Mpanga, (2016). However, knowledge on adaptive capacity of hydropower organisations to cope with climate change effects at river basin level is fragmentary and remains scant in the Southern African region, particularly in the Kafue River Basin. Moreover, most studies usually concentrate on empirical analysis of statistical models and not on adaptive capacity of water user organisations especially at river basin level.

Understanding adaptive capacity from climate change perspective is remarkably not a straightforward issue (Alberini et al., 2006; Barton, 2013: Mark Pelling, 2011). The question is, do we have choices for coping with climate change? (O'Brien, 2012). Research on adaptive capacity increasingly attempts to suggest how best to adapt to drought. Responses can be made by the reaction to exposure or in anticipation of exposure. The very concept of diversity in ecology, complex system theory and natural resources management apply in climate change related adaptations (Ostrom, 2005; Bell et al., 2011; Page, 2011). Such responses can be based on assessments of new and existing technologies (Yohe & Tol, 2002; Brooks et al., 2005; Alberini, 2006).

Challenges posed by climate change impacts on river basins are manifold (IPCC, 2007). Many hydropower organisation in Southern Africa depend on hydro as a main source of power generation such that changes in water resources alter the generation (Hamududu & Killingtveit, 2016). While some areas witness intense rainfall, others experience erratic rainfall with frequent droughts (Huntjens et al., 2010). Impacts of climate change are ultimately experienced through water. Climate change will soon alter the timing, quantity and quality of water resources, and increase risks and uncertainties. In such situations therefore, both responsive and anticipatory water governance is vital to such conditions (Tarlock & Wouters, 2009; Honkonen, 2016). Given the growing recognition of the need to adapt to the impacts of climate change, water managers are expected to be experts on adapting to climate change (Bates et al., 2008; Grafton & Hussey, 2011). As such, when discussing the adaptive capacity of SES such as hydropower organisations to the impacts of climate change, at least the following four questions need to be answered: Adapt to what? What to adapt? When to adapt? What conditions are there for adaptation? (Strezepek & Smith, 1995; Smith, 1996). Therefore, while water resources are increasingly stressed by climate change, the adaptive coping capacity of hydropower organisations and other water users is critical (Engle & Lemos, 2012).

Adaptation and mitigation are the two main responses of the international climate change regime. In fact, the UN framework conversion on climate change (UNFCCC) claims some of the best response methods are those of enhancing adaptive capacity, strengthening resilience, and reducing vulnerability to climate change (Honkonen, 2016). Climate change has largely been regarded as a change in water cycle. While climate change impacts on all the features of water, the fact that water is an essential component of the climate system can never be in doubt. Hence, changes in the timing of water and the quantity as well as quality of water resources translate into risks to water security (Honkonen, 2016).

2.8 COMPONENTS OF ADAPTIVE CAPACITY

Adaptive capacity is related to a system's available short-term coping mechanisms and long-term adaptation strategies (Smit & Wandel, 2006; Engle & Lemos, 2010; Brooks et al., 2005). The adaptive capacity of a system to climate change associated hazards (e.g. drought) depends on that system's ability to gain access to a wide range of available technologies. Adaptive capacity is determined by the characteristics of an organisation (system) that influences its ability to adapt (Adger, 2005; IPCC, 2007; Pelling, 2011; Hinkel, 2011). Adaptive capacity is analysed through indicators or determinants which include: technology, institutions, infrastructure, finances, networks, and others (Adger et al., 2003; IPCC, 2001; Engle & Lemos, 2010), as shown in Figure 2.1 below.

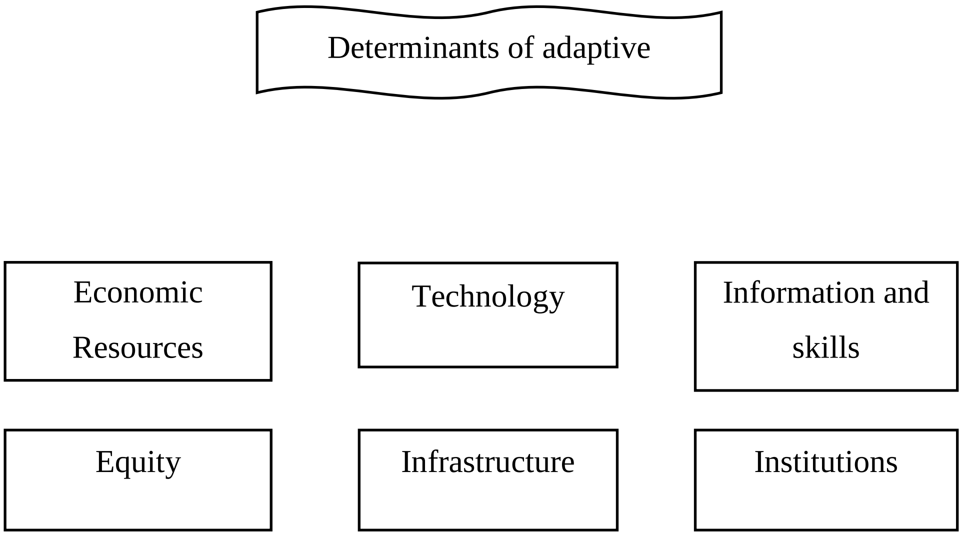

FIGURE 2.1: DETERMINANTS OF ADAPTIVE CAPACITY

(Adapted from: IPCC, 2001; Eakin & Lemos 2006; Engle & Lemos, 2010)

For the purpose of this study, the technology component was used to determine adaptive capacity because it is the major component influencing hydropower organisation in the case study. It plays a significant role in shaping adaptive capacity to drought. The three dimensions of technology in this case are: diversification, location and size.

2.9 TECHNOLOGY AS COMPONENT OF ADAPTIVE CAPACITY

Dealing with adaptive capacity in relation to climate change is complex (O'Brien et al., 2005; Barton, 2013; Pelling, 2011). The technology of hydropower organisation is important in that climate change threats, particularly drought, is responded to by enhancing adaptive capacity, which helps to provide more adaptation alternatives for the future. In this sense, exploring available technology for climate change reinforces the need to address the adaptive capacities of hydropower organisations, which are the major water users at river basin level, and have an influence on water security. Managing water for adaptive capacity is also important for water security in the sense that when water is not able to support normal hydropower generation during drought, that already reflects low water security in the basin. Its key benefit is to assess how technology can be altered regarding diversification, capacity and location, in order to respond to drought. In particular, questions have been raised regarding whether water users such as hydropower organisations actually have the capacity to adapt to complex and non-linear climate change impacts, particularly drought. Research on adaptive capacity increasingly attempts to suggest how best to respond and adapt to drought. Responses made are in reaction to exposure, or anticipation of exposure (O'Brien, 2012). Responses made in reaction to a change may include power imports, load shedding, and reducing power generation (IAPRI, 2016). Anticipatory responses may include diversification of technology in terms of improvements to and expansion of technology. Such responses are often based on assessments of new and existing technology (Yohe & Tol, 2002; Brooks et al., 2005). This perspective thus predicts good adaptive capacity if technologies provide a basis for drought adaptation mechanisms (Alberini, 2006).

2.10 WATER USER ORGANISATIONS

Fresh water resources in many river basins are used by various water user organisations with varying interests (Biswas, 2008; Lankford et al., 2013). Water users make efforts to create adaptive capacity to climate change effects in the effort to attain water security and continue to function properly (IPCC, 2007). The hydropower organisations are among major water users directly affected by drought. For instance, ZESCO's power generation in the Kafue River Basin has been under stress through drought-associated climate change (Yamba 2011; Muzeya, 2014; IAPRI, 2015; Mpanga, 2016). Other water user groups include municipalities, water utility companies, the food and beverage industry, fishing, wildlife, agriculture, mining and tourism, among many others (WWF, 2013). Drought has purportedly lowered water levels in the basin. As a result, the low water levels reduce the amount and flow of water in the river, thereby creating insufficient force and amounts required for hydropower generation (ZESCO, 2012). Consequently, this has caused ZESCO to reduce its power generation and thus there is a decrease in the generation of hydropower (Yamba 2011; ZESCO, 2012; Muzeya, 2014; IAPRI, 2015; Mpanga, 2016).

The low availability of water in the river basins is a threat to water security (Alavian et al., 2009). Water security tend to be directly threatened in the river basins once water users suffer from inadequate adaptive capacity to drought. According to Bates, et al. (2008), water quantity refers to the volume of available water in the ecosystem controlled through the balance of inflows (precipitation, groundwater seepage, and runoff) and outflows (water abstractions, natural outflows, evapotranspiration). Given that hydropower organisation depends on water and are sensitive to the effects of climate change, they are at high risk of being severely stressed (Kabat et al., 2003; Kundzewicz, et al., 2007; Muzeya, 2014; IAPRI, 2015, Mpanga, 2016).

Enhancing the adaptive capacity of hydropower organisations entails improving some preferred system characteristics and behaviours. An organisation has adaptive capacity if it prevents the ecological systems upon which it depends from moving into collapse by sustaining the system's functioning and maintaining its productivity (Ostrom, 1990). In the event of drought, water users actively need to monitor and audit the condition of water resources in order to create adaptive capacity (Kabat et al., 2003). Resource users need to act collectively in order to identify new and existing technologies for adaptation, river flow and the available quantity and quality, water utilisation patterns and other water security issues. Moreover, when there is good management of water by users, climate change shocks can be reduced. So, while climate change dynamics may change over time, water user organisations must develop capacities to adapt to changes in order to enhance water security (Ostrom, 1990; Anderies et al., 2004: Ostrom, 2005).

2.11 HYDROPOWER ORGANISATIONAL IDENTITY AND IMAGE

Hydropower organisations are portrayed in various ways. The concepts of organisational identity, culture, image and vision have attained the status of key concepts used to ascertain the character and behaviours of hydropower organisations (Whetten & Godfrey, 1998; Gioia et al., 2000). Image, in the sense of a holistic impression of an organisation, is always at the forefront, while attitudes, perceptions, opinions, views, and meanings are often understood in a sociological and historical manner (Ashforth & Mael, 1989; Alvesson, 1990). However, the character of an organisation is chiefly about its identity.

Many scholars hold the notion that organisational image is the way in which members of an organisation believe others see the organisation-the public perception (Dutton and Dukerich, 1991). Organisational identity is the collective understanding of features presumed to be central, that distinguish one organisation from another. Organisations tend to maintain their image and protect their identity, particularly when threatened by change. Typically, the organisation can choose to remain as they have always been, or change in order to preserve their identity. For example, ZESCO maintains its character of being a hydropower organisation (Gioia et al., 2000). Organisational image is the way its members believe others view the organisation. Image represents vital features of organisational identity to others (Dutton & Dukerich, 1991), and refers to a construction of public impressions created to appeal to an audience (Gioia et al., 2000). Organisations, to a large extent, send out messages that communicate flattering images in the minds of various target groups. In building organisational image, many activities, events and structures are crucial to the achievement of organisational efficiency (Alvesson, 1990; Gioia et al., 2000).

Environmental instability can offer certain benefits to organisations, since it allows better adaptation to the demands of a continuously changing environment. Organisations can be proactive in pursuing change, even in the absence of environmental stress. However, to induce change, the organisation must take a different approach. In addition, it is believed that an organisation can hardly change if it is complacent about its character (Whetten & Godfrey, 1998; Gioia et al., 2000).

2.12 CONCLUSION

This chapter has set out the relevant literature of the study. In the first section, emphasis was placed on the literature dealing with theories surrounding climate change in the domain of social ecological systems, its proponents, and the current debates on climate change research. Many scholars have stated the importance of adaptive capacity in coping with climate change and its significance in enabling SES to be robust. The literature on socio-ecological systems and its promoters shows that SES (hydropower organisations) are highly vulnerable to the impacts of climate change because they entirely depend on water, through which climate change manifests. The literature on water management and water security was also discussed in light of the current debates. Also indicated were the uncertainties and risks posed by climate change on water security and management. Water management and planning can not only help develop mechanisms suitable for climate change adaptations, it can also serve to advance potential solutions such as IWRM by addressing changing water resources in river basins and patterns arising from the growing demand (Grafton & Hussey, 2011). Thereafter, the concepts of adaptive capacity and adaptation to assess the prerequisites for climate change adaptation were discussed. As explained by several authors, the determinants of adaptive capacity must be available to enhance adaptive capacity. Thus, the chapter focused on the technological component of adaptive capacity. It is important to note that since the concept of adaptive capacity is generally studied alongside the concepts of vulnerability and resilience, they too were discussed. At the end of the chapter, the literature on water user organisations was considered, with emphasis on those organisations in the Kafue River Basin, particularly hydropower organisations and their organisational identity and image. The following chapter describes and justifies the research methodology used in this study.

3 CHAPTER THREE - STUDY SETTINGS AND METHODOLOGY

3.1 INTRODUCTION

This chapter describes the study site and the methodology used. To begin with, the chapter describes the Kafue River Basin as the study area, and ZESCO organisation as the case study. The chapter later explains the specific methods and approaches that were used to achieve the intend purpose of this study. The interpretivist paradigm and its relevance to the study is then discussed. The chapter also justifies the field research and case study approach used in the research process. Finally, the chapter explains how data was collected through interviews and documentary analysis. In addition, the manner in which trustworthiness of the study was achieved, and how ethical considerations were adhered to, is outlined. The limitations of the study are then described in the final section of this chapter.

3.2 DESCRIPTION OF THE STUDY AREA

3.2.1 CLIMATE AND WEATHER PATTERNS

The Kafue River Basin has a tropical climate with three distinct seasons: the warm-wet season from November to April; the cool dry cold season from May to August with mean temperatures between 14 and 30 degrees Celsius. The hot dry season is experienced between September and October. Annual rainfall averages 1240 mm mostly falling in the months of December to February (ZESCO, 2011). Over the last four decades, the Kafue Basin has experienced an increased mean annual temperature of 1.3 degrees C, and a decreased mean rainfall of 1.9 mm/month causing the Kafue River to dry, whereas rainfall seasons have become less predictable and shorter, with rainfall occurring in fewer but more intense events. From 2000 to 2007, the intensity and frequency of floods increased. The 2004/05 drought left nearly two thirds of the country with little or no rainfall and the 2014/2016 drought affected the entire country (WWF, 2013).

3.2.2 GEOGRAPHIC LOCATION AND SOCIO-ECONOMIC IMPORTANCE

The Kafue River Basin plays a central role in Zambia's economy and in most of the nation's mining, industrial, and agricultural activities. Approximately 50% of Zambia's total population is concentrated within the basin area. The area of the Kafue River drainage basin measures about 156,000 square kilometres and lies entirely within the borders of Zambia, occupying about 20% of Zambia's total land. The river originates in the Copperbelt Province and terminates at its confluence with the Zambezi River. The Kafue Flats is a wide and flat section of the river, with natural water flowing slowly across the flats at a shallow depth. It is a vast, open floodplain, covering about 6,500 square kilometres and is important for fishing, cattle grazing, sugarcane farming, and the production of hydroelectric power (WWF, 2013; Nkhata et al 2014).

The Kafue Flats is home to 9% of the Zambian population: 73% is rural and directly dependent on the ecological function and flow regime of the Flats. Tourism represents between 6%–10% of the economy (WWF, 2013). The food and beverage industry is dependent on the Kafue Flats. Irrigation accounts for 73% of water withdrawal with the majority taking place within the Kafue Flats, where large tracts of sugarcane are irrigated. Agricultural foods such as maize, beef, fish, milk and sugar are all grown in the Kafue Flats region (WWF, 2013). Hydropower is generated from the Kafue Flats, with mining being the major user. The Kafue Gorge hydroelectric power plant, situated at the eastern end of the Kafue Flats, is the country's largest power station, providing more than 50 per cent of Zambia's electricity. The Kafue Gorge Dam produces 990 megawatts of power for the national grid. The mines are the major consumers of electricity, accounting for 68%, followed by households, which use 19%. The basin supplies water to many cities, including Lusaka (ZESCO, 2012).

3.2.3 THE KAFUE RIVER

The Kafue River is one of the major tributaries of the Zambezi River. The total length of the Kafue River is about 1,500 kilometres. The river originates at the Zambia-Congo divide. It flows south-westwards, close to the Lukanga Swamps, and into the Itezhi-Tezhi reservoir. The Kafue River then turns eastwards and flows for about 350 kilometres across the Kafue Flats and into the Kafue Gorge Upper reservoir.

3.2.4 STAKEHOLDERS IN THE KAFUE RIVER BASIN

Major stakeholders include the Ministries of Finance and National Planning, Water and Energy, Agriculture, Tourism and Environment. Additional stakeholders comprise NGOs, the Zambia Wildlife Authority, Zambia Sugar, and the World Wildlife Fund for Nature. Institutional arrangements within the basin are complex due to various actors being involved in different aspects of the economy (Nkhata et al., 2014).

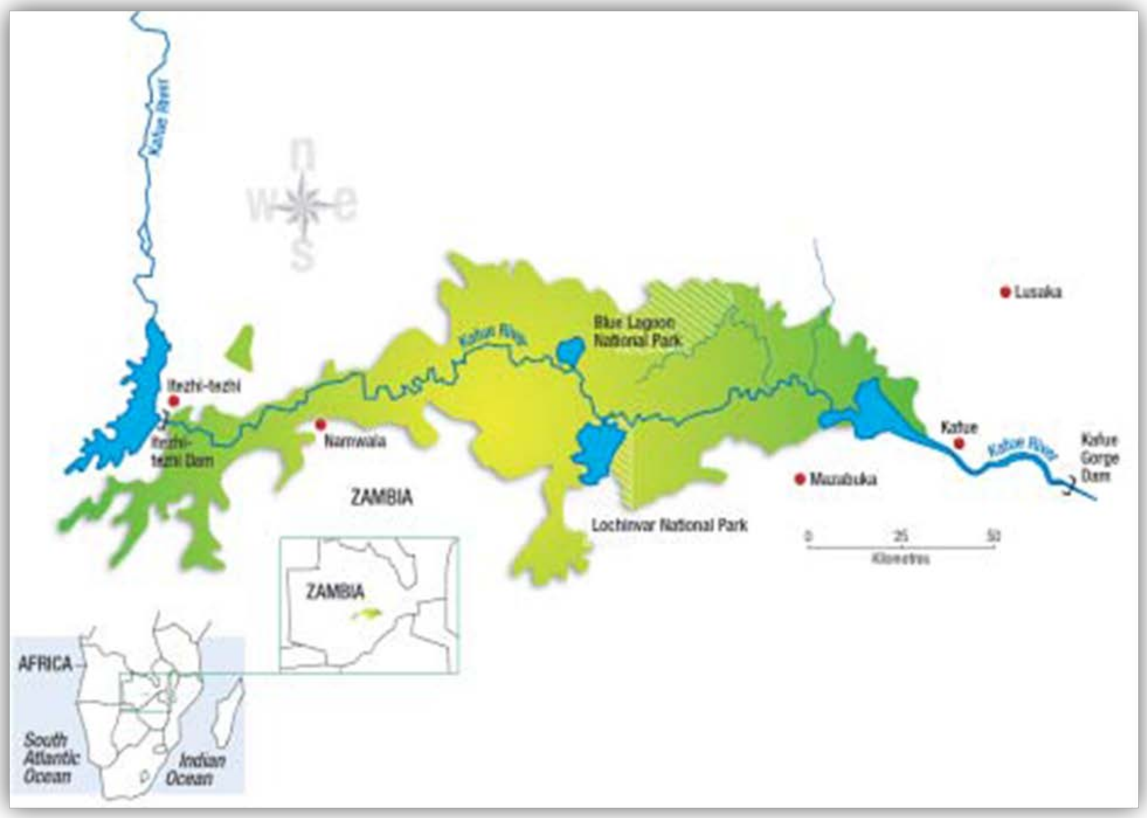

FIGURE 3.1: MAP OF THE STUDY AREA

(Source: WWF, 2013)

3.2.5 SELECTION OF THE STUDY AREA AND ORGANISATION

For the purpose of this study, the Kafue River Basin was the selected case study because it is one of the prescribed areas under the International Water Security Network project (Nkhata et al., 2014). ZESCO's Kafue Gorge Upper Power Station is situated on the downstream of the Kafue Flats. It is a suitable case study because ZESCO is a major water user and thus is sensitive to climate change effects. Owned by the state, ZESCO is a utility organisation involved in the generation, transmission, distribution and supply of electricity. It is a major producer of hydropower in Zambia. Moreover, the organisation shows evidence of low power production during prolonged drought. ZESCO is a major producer of hydropower energy in Zambia. It anchors all the economic activities such as the extractive, processing and service industries, and hence is significant to the economy. Furthermore, this organisation supplies power to neighbouring countries such as the Democratic Republic of Congo and Namibia, has connections with its Zimbabwe counterpart, and plays a vital role in contributing to Zambia's Gross Domestic Product (GDP) (ZESCO, 2012). However, the organisation shows evidence of low power production during drought episodes and exhibits low adaptive capacity in responding to drought thus, making it a suitable case study for this research.

Additionally, ZESCO organisation was chosen as a case study because of the possession of 'technology' component of adaptive capacity to cope with drought. On top of droughts and its use of hydropower technology, ZESCO makes a good and interesting case to study how it intends to adapt to drought using other means of technology available and develop the current type.

3.3 RESEARCH PARADIGM (INTERPRETIVISM)

According to Bryman (2012), a paradigm is essentially a frame of reference that dictates what scientists study, how research is conducted, and how results are interpreted. This study was influenced by the interpretivist paradigm which is mostly applicable in the social sciences qualitative research. This paradigm emphasises words rather than numbers. It is influenced by many traditions such as hermeneutic phenomenology, which aims to gain in-depth understanding of a phenomenon. It determines what questions are considered worthy of study and the processes needed to generate the associated answers. It is a well-known paradigm and is used in qualitative studies such as anthropology and ethnographic case study research (du Plooy-Cilliers, 2014; Bryman 2012). Interpretivists believe that social reality is composed of meaningful actions, artefacts and events that need to be understood from different perspectives. As such, interpreting and gaining in-depth understanding of human actions and events was critical in this study (Bryman, 2012; du Plooy-Cilliers, 2014). Based on the interpretivist paradigm, this study was conducted in field settings that captured the human experience. ZESCO in the Kafue River Basin, and particularly the Kafue Gorge Upper Power Plant, were used as the study framework to assess and observe adaptive capacity and climate change phenomena in a natural environment (Babbie, 2013: Strydom & Bezuidenhout, 2014).

3.4 FIELD RESEARCH

Field research is a well-known method used in case studies involving people and natural environments. This study being qualitative in nature, field research was suitable to assess adaptive capacity and climate change phenomena in a natural environment (Babbie, 2013: Strydom & Bezuidenhout, 2014). Field research requires a researcher to go where the action is taking place, and involves making actual observations and listening in order to provide greater validity and gain insights into the nature of human efforts (Babbie, 2013).

3.5 CASE STUDY APPROACH

A case study approach provides a rich and detailed description of a social phenomenon that is to be studied within the real world. The purpose of case study research is to intensively study a single case in order to infer idiosyncratic knowledge. The approach was applicable to this study as it allowed a deep exploration within a natural context and provided a thorough understanding of the data collection needed an exploratory case study was also used in an attempt to rigorously assess the impacts of climate change phenomena within specific circumstances. This approach was appropriate to the purpose of the study as it looks only at one entity (ZESCO) in the case study (du Plooy-Cilliers et al., 2014). It was also applicable because this study involved an examination of a single instance of a social phenomenon within a formal organisation. This involved in-depth study of a case to yield explanatory insights (Babbie, 2013).

3.6 DATA COLLECTION

3.6.1 DOCUMENTARY ANALYSIS

Textual data involving written words and verbal responses during interviews and in field notes, were significant to this study as they conveyed potential meanings. Document analysis refers to the systematic collection, review and evaluation of documents, both in soft and hard copies, so as to elucidate meaning (du Plooy-Cilliers et al., 2014). It involves information that the researcher obtains from non-observable and other secondary sources. Such information is collected mostly through reviewing the literature and desktop studies. Document analysis was conducted for this study through the use of articles, books, government and United Nations documents, ZESCO documents, and other relevant material. It provided a context in which the research participants could operate through historical insight, and a means of refining the interview questions based on new insights on the phenomenon. It also provided ways for tracking change in ZESCO and its organisational development. The review of documentary materials comprised the analysis of documents in order to enrich the interviews.

3.6.2 IN-DEPTH INTERVIEWS

An interview is a two-way conversation between the interviewer and the participant (interviewee) (Babbie, 2013). It is a qualitative field study technique for data collection which allows a researcher to pose open-ended questions to participants with the aim of learning more about their views, opinions, feelings, beliefs, experiences and knowledge to the questions of the study (du Plooy-Cilliers et al., 2014). Interviews are a valuable source of data that allows deep interpretation and understanding of the meanings held by participants, and are recommended as a particularly useful tool for case studies. The primary aim of using interviews in this study was to obtain in-depth and detailed data based on open-ended questions about adaptive capacities, available technologies and climate change effects. Moreover, the interviews provided detailed explanations on specific questions through the set of topics discussed in depth. They gave an opportunity to ask more in-depth questions, allowing more flexibility in the research process. Above all, the interviews enabled the researcher to be present at the scene of action. They also allowed flexibility in that the researcher could modify the questions at any time (Babbie, 2013; du Plooy-Cilliers et al., 2014). Primary data was useful because the study involved questions to the participants in the field. The unit of study was hydropower water user organisation; the unit of observation was the individual managers. Potential participants were the managers of different departments at Kafue Gorge Upper Hydropower Station, who were identified during face to face meetings as part of a reconnaissance survey preceding data collection. Managers were selected as participants because they head key departments at ZESCO and as overall information keepers, they had access to most of the required data. In order to validate the data among the four respondents, in-depth qualitative interviews were conducted with four participants representing key departments at ZESCO. This is important because data from each one participant can be used to compare and confirm with others to have clear and in-depth facts about the phenomena. Interviews took place during the period of March 2016. Interviews were conducted until reaching saturation point. Saturation point is a point where respondents give similar patterns of data such that the difference is not significant to extracted new themes from data (Babbie, 2013). Participants were from the following departments: Hydrology, Generation and Transmission, and Environmental and Social affairs.

TABLE 3.1: KEY INFORMANTS

Position	**Department**	**Experience**	**Type of information**
Chief Engineer	**Hydrology**	**Over 10 years**	• Climate and weather data • Hydrometric network • Focus on water availability • River flows and water levels

Manager	Environment and safety	Over 10 years	• ZESCO's hydropower • Diversification of technology • Climate change challenges
Senior Manager	Generation Support Services	Over 15 years	• ZESCO organisations • Available water use technologies • Adaptation mechanisms • Projects and Investments
Senior Manager	Environment, Safety and Integrated Management Systems	Over 15 years	• Adaptation mechanism • Effects of climate change and climate variability

3.6.2.1 INTERVIEW APPROACH

The interview process for this study involved the following steps: identification of respondents; initiating contact with identified respondents; and conducting the interviews. Each participant was formally approached and appointments were made prior to the interviews. Interviews were conversational and participants supplied data freely when responding to the questions. This gave a degree of freedom to participants and allowed the researcher to adjust the focus when necessary, Interviews were conducted in the participants' offices which provided them a quiet and comfortable environment. Over four days, one participant per day was interviewed. Each interview took about 30 minutes and was conducted in English. The participants had been provided with pre-prepared guiding questions. The participants involved in this study are shown in table 3.2 below. Interview questions were open-ended (semi structured) so that participants were not limited in their responses. Data was collected by writing in a field notebook in English. Voice data was collected by recording the voice text using a digital voice recorder during the conversations. Interviews were semi-structured to provide ample time for the interviewees to fully express their own opinions and thoughts without limitations (du Plooy-Cilliers et al., 2014. Most importantly, the interviews provided an understanding of the adaptive capacity of ZESCO to coping with drought.

TABLE 3.2: DATA COLLECTION GUIDING TOPICS

MAIN TOPIC	SECTIONS
WEATHER AND CLIMATE	• Monitoring systems • Weather and climate forecasting • Climate change and variability • Extent of drought in Zambia
DIVERSIFICATION OF TECHNOLOGY	• The mechanisms in which ZESCO is trying to diversify its technology • Warning system (water availability and drought) • Solar power technology adaptation • Wind power technology adaptation • Thermal power technology adaptation • Infrastructure and materials
LOCATION OF TECHNOLOGY	• The Kafue River Basin • The Congo River Basin • Climatic zone of Zambia • Location of current and future power plants
CAPACITY OF TECHNOLOGY	• Constructions of new power plants • Expansion of the existing power plants • ZESCO's current and expected generation capacity

(Source: Engle 2010)

3.7 DATA ANALYSIS AND INTERPRETATION

Qualitative data analysis is a process of bringing order, structure and meaning to a mass of data. In this study, data analysis was started by organising meaningful information through identifying themes and significant patterns from the questionnaire answers. Interpretation of the meaning and substantiation of data was extensively undertaken. During data analysis and interpretation, deep reading of text was conducted. An iterative method was performed by repeating the analysis and interpretation over and over in a cycle to isolate the embedded meanings. This helped identify emerging patterns in the text and attained a deep and thorough understanding of the meanings of the patterns. Transcription was used through coding and converting the data into a written format. Recorded data was retyped word for word in order to analyse it in textual form (Bezuidenhout & Cronje, 2014). Through these processes, the findings emerged.

Textual analysis is a qualitative method for the subjective interpretation of the data through a systematic classification process of coding and identifying themes or patterns. It is a qualitative method involving systematic analysis to provide an in-depth understanding of the text. This technique was useful in the study as it explored, identified and converted themes and patterns embedded in the text, with attention to the meanings (Bezuidenhout & Cronje, 2014). It categorised the data according to themes from broad, general observations to more specific aspects. As the study was being influenced by the interpretivist paradigm, coding provided a basis for a detailed description of the research phenomena. This method was effective when looking at textual content such as the transcripts. The focus was on the textual content from the field notes and the spoken words from the digital voice recorder. Therefore, following the actual qualitative text analysis, steps were taken to: prepare the data, define the coding units to be analysed, develop categories and coding schemes, test coding schemes, assess coding consistency, draw conclusions from the coded data, report the findings, and present them in the form of themes and categories from most important to least important (Bezuidenhout &Cronje, 2014). In addition, as the coding was systematic, the coding categories were based on the theoretical and conceptual framework employing more of open coding system.

3.8 TRUSTWORTHINESS

Trustworthiness in qualitative research is also known as reliability and validity. It is vital for a study to have credibility, transferability, dependability and conformability (Koonin, 2014). Credibility was an important aspect of this study because the data provided by participants needed to be accurately interpreted. This was achieved by spending time with the participants prior to the interviews in order to understand them better. The information they gave was based on what they meant, and not on the researcher's subjective feelings and perceptions. This helped to steer the research process by creating good relationships and trust. The researcher was open about the study's purpose and made it clear to participants that they were part of the research. They were assured that their identities would be protected with confidentiality (Koonin, 2014). Transferability is the ability of the findings to be applied to similar situations and deliver similar results to aid generalisation. It is vital in field studies as it renders the study methods and results able to be used elsewhere in similar cases. Transferability is a requirement in qualitative studies, and was achieved in the study through developing good research methodology (Koonin, 2014). Dependability is a quality of the integration process that takes place between data collection methods, data analysis and the theory generated from the data. Confirmability has to do with how well the collected data supports the study findings and interpretation of the researcher. Therefore, this study described the research methodology and design in order to assist other researchers who might need to repeat the same research and find similar results (Koonin, 2014).

3.9 ETHICS

It was important to recognise potential ethical issues during the study. Ethics are vital in establishing the feasibility of a study. The research proposal was submitted to Monash University Human Research Ethics Committee for clearance. All the ethics procedures were followed before commencing data collection. Ethical issues were considered for the researcher/participant relationship, the researcher's subjective interpretation of the data, and the design. In an explanatory statement given to participants prior to the interviews, the purpose of the study and any possible risk was outlined. Consent was sought from participants by using a consent form. The information collected remained confidential and secure during and after the research. Only the researcher and the supervisors had access to the study data and information. All findings and results presented stemmed from actual facts stated in the interviews. All participants' experiences and perceptions were depicted precisely as they appeared in the interviews.

3.10 LIMITATIONS OF THE STUDY

ZESCO limited the number of respondents from the requested ten to four, due to the sensitivity of the data. Data collection came at a time when the organisation was under the influence of political pressure from the government and other stakeholders due to the prevailing power outages resulting from low water levels in the river basins, and causing ZESCO to reduce its power generation. As this affected all sectors of the economy, ZESCO became sensitive about revealing information. This attitude affected the results of the study, although not significantly, as alternatives ways were employed.

The organisation's consent for data collection was delayed and the process to obtain it was very long. The organisation had to follow its correct procedural policy to assess the application in terms of content and the data collection tools. The time consumed by this process was a limitation as it reduced the data collection time.

Another limitation was the fact that in the study, technology alone was considered the important variable influencing adaptive capacity. However, it must be noted that there are several other determinants of adaptive capacity that work together with technology and complement each other to achieve the desired adaptive capacity. These are explicitly elaborated upon in the adaptive capacity framework (see for example, IPCC, 2001; Eakin & Lemos 2006; Engle & Lemos, 2010), which identifies six major determinants of adaptive capacity that must be available as prerequisites: namely, infrastructure, economic resources, equity, institutions, information, and technology itself. In addition, the framework also recognises external limitations of adaptive capacity, which demands that further research be undertaken. Therefore, although this study is premised on determining adaptive capacity, it only infers its conclusions on the technology component of adaptive capacity. Nonetheless, the study proposes recommendations to carry out research involving the other determinants of adaptive capacity.

3.11 CONCLUSION

The main goal of this chapter was to present the study site and methodology. The Kafue River Basin was described as the study area where this research was carried out, and particular mention was made of the ZESCO organisation, which was used as the case study. It is clear that the Kafue River Basin anchors the economy of Zambia through mining, agriculture hydropower generation and water utilities. The chapter then explained the specific methods and approaches that were used to achieve the intended purpose of the study. The interpretivist paradigm and its significance to the study were justified. This chapter also made clear that the field research and the case study approach were used to gain insights into drought and its impacts on SES in the river basin. The chapter described how data from the interviews and documents was analysed using the textual analysis method. Trustworthiness of the study was discussed, and how it conformed to the accepted ethics and the limitations of the study.

4 CHAPTER FOUR - RESULTS

4.1 INTRODUCTION

The purpose of this chapter is to present the results of the study. The study aimed at exploring the prerequisites of adaptive capacity for hydropower organisations to cope with the effects of climate change, particularly drought. The study focused on the technology component of adaptive capacity. It particularly attempted to explore how ZESCO is enhancing the conditions necessary for creating adaptive capacity through available technology, from short-term adjustments (or coping strategies), to long-term adaptation strategies. The study revealed that three technological prerequisites were proposed to enhance ZESCO's adaptive capacity to cope with drought: (i) diversification of technology (ii) expansion of the generation capacity through construction and upgrading (iii) location of the technology to less drought-prone areas.

Firstly, the findings on how diversification of technology plays a role in creating necessary conditions for adaptive capacity are presented. ZESCO is particularly prioritising diversification in order to achieve high adaptive capacity to drought. The company is resorting to non-hydro technologies such as thermal, solar and wind power, aimed at increasing access to a diverse range (mix) of technologies which will reduce their dependence on hydropower. Secondly, the findings show that technology expansion is an important prerequisite for adaptive capacity to drought. ZESCO is expanding their technology by the way of constructing new technologies and upgrading their existing technologies. Thirdly, I present results on how Location plays a role in creating conditions essential for promoting adaptive capacity, and ZESCO is creating additional ability to cope with drought by locating new technologies in various river basins that are perceived to be less prone to drought. Finally, the reasons why it has taken so long for ZESCO to create conditions for enhancing adaptive capacity are shown.

Adaptive capacity in this study is defined as the ability or capacity of a system (organisation) to cope with existing and or anticipated climate change stresses such as drought. Adaptation refers to adjustments in a system's behaviour and characteristics that enhance its ability to cope with drought (Smit and Pilifosova, 2003). In the context of this study, the adaptive capacity of ZESCO to cope with drought depends on the organisation's ability to gain access to a wide range of technologies. Adaptive capacity is determined by the characteristics of an organisation (system) that influence its ability to adapt (Adger, 2005; Pelling, 2011; Hinkel, 2011). As adaptive capacity is analysed through its determinants, which include: technology, institutions, infrastructure, finances and networks (see Figure 1.1 in Chapter Two), this study draws from the premise to determine ZESCO's ability based on the technology component (IPCC, 2001; Adger et al., 2003; Eakin & Lemos 2006; Engle & Lemos, 2010).

The technology component was used to determine adaptive capacity because it is the major component influencing drought response. Technology plays a significant role in shaping adaptive capacity to drought by using three dimensions: diversification, location and size. Thus, the concept of adaptive capacity in the context of this study entails the ability of hydropower organisations to increase power generation capacity (size), enrich diversification of limited technology, and finally vary the location of the technologies. An organisation can be regarded as having low adaptive capacity if it has no available range of technologies as adaptation options to cope with drought. The technology analysed was non-hydro, for appropriateness and flexibility. Therefore, if there are no different types of technology options available, it suggests that adaptive capacity is likely to be low, just as when there is no expansion of existing technologies or construction of new ones, capacity will be low.

4.2 DIVERSIFICATION OF TECHNOLOGY

The study found that diversification of technology can provide preconditions for hydropower organisations to enhance adaptive capacity. Diversification of technology plays an important role in creating the conditions necessary to effectively respond to drought. Diversifying hydropower to other types of technologies such as solar, wind and thermal technologies can improve the conditions necessary for increasing adaptive capacity to cope with drought. The explicit aim of diversifying technology is to increase the mix of different types of power plants in order to reduce the impacts of drought on hydro, in this case, power generation technology (IEA, 2008; Mpanga et al., 2016). Therefore, technology diversification is appropriate to act as a prerequisite for enhancing adaptive capacity. In so doing, an organisation must have access to different types of power plants which are specifically non-hydro and available as alternative options for generating power during drought. ZESCO is diversifying its technology in order to adapt effectively.As a hydropower organisation, ZESCO has high dependence on just one type of technology (hydro technology), and this lack of diversification faces them with huge drought challenges. The company's motive for diversifying its technology is to respond to drought and enhance adaptive capacity.

When an organisation entirely depends on hydro, it is prone to drought and tends to reduce power generation because they have no alternative non-hydro technologies. Data from the Energy Regulation Board (ERB) revealed that ZESCO's technology is dominated by hydro.

ZESCO is about 99% hydro technology and 1% of others, comprising diesel, thermal, solar and heavy fuel oil (HFO), as shown in the table below.

TABLE 4.1: TOTAL INSTALLED POWER GENERATION CAPACITY OF ZESCO

Type of technology	Total capacity installed (MW)	Percentage (%)
Hydro	2255	99
Thermal	80	1
Solar	0.06	
Diesel	11	

(Source: ERB 2014; Personal interview, 2016)

Table 4.1 indicates that ZESCO is characterised by little technological diversity, thus low power generation and shortages are exacerbated. This can be attributed to low investment. One of the Senior Managers at ZESCO revealed that during drought, the organisation's ability to generate normal power is highly impaired because of its lack of diversity and complete dependence on hydro. ZESCO is 99% dependent on hydro, rendering it susceptible to low levels of adaptive capacity when responding to drought. Thus, the company's intention to diversify technology is important as it will increase the mix of technology, avoid drought and enhance adaptive capacity.

> *The challenges that we are facing now are looking at several factors. Like I mentioned that we are relying on almost 100% hydro. The thinking now is that we want to have a mix. We want to bring in other sources of energy which are not hydro technology dependant as ZESCO's electricity generation capacity stands slightly above 2000 MW, 99% is hydro.* (Interview 1T, ZESCO, 15 March 2016).

Diversification of technology involves having in place variety of power plants and the installation of different types of non-hydro technology. As a result of drought, the study attempted to find out how ZESCO is enhancing adaptive capacity through the available technology options. I therefore asked the respondents what key technology options are available to the company, and how appropriate and effective they are likely to be in addressing the problems of drought. Following a personal interview with one of the Senior Managers at ZESCO regarding technology strategies, he stated that ZESCO has many technology strategies currently available which include diversification of technology;

> *There are many strategies put in place to deal with the current drought and avoid the same situation to occur. Many of these strategies involve diversification of technology by employing different types of technologies to produce power.* (Interview 2S, ZESCO, 16 March 2016).

The manager added that being 99% reliant on hydro is challenging and has been contributing to drought problems. At the time of the 2015 droughts, ZESCO realised it needed to diversify to other alternative forms of technology to enhance the mix and create the conditions vital to achieve adaptive capacity:

> *If you asked me 2 years ago about solar energy, thermal or any other, I would tell you that we are a hydropower based industry. Now we are no longer like that, we have changed our strategy. We are now looking at alternative sources such as solar, thermal and wind energy sources.* (Interview 3T. ZESCO, 16 March 2016).

The diversification that ZESCO plans to start implementing involves different types of technologies, as shown in Table 4.2. In an interview with Zambia's National Broadcasting Corporation (ZNBC), ZESCO's public relations manager mentioned that ZESCO is looking forward to practicing an energy mix of the kind that is believed to cushion power deficits (Public Relations Manager, 2016). Technology diversification is one of the long-term adaptation strategies being undertaken to add variety to existing hydropower technology and enhance adaptive capacity.

TABLE 4.2: TYPES OF AVAILABLE ADAPTATION TECHNOLOGIES AND THEIR GENERATION CAPACITY

Type of Technology	**Status**	**Expected Generation Capacity**
Hydro technology	• Available for diversification • already in use	• 6000 MW potential
Thermal technology	• Available for diversification • over 80 million tons of coal	• Over 1000 MW potential

	• 300 MW projects underway	
Solar technology	• Available for diversification • Average solar insolation of 5.5 kWh/m2/day • 50-100 MW projects underway	• Over 1000 MW potential
Wind technology	• Available for diversification • Average speed of wind 2.5 m/s • wind resource mapping ongoing	• over 1000 MW potential

(Sources: ZDA, 2013; Muzeya, 2015; Personal Interview, 2016; Mpanga *et al*., 2016)

Table 4.2 clearly indicates that ZESCO is intending to diversify into three types of non-hydro technology, which include thermal, solar and wind power technologies. These are adaptation options available for responding to drought. ZESCO in the recent past has been very comfortable with hydropower technology due to the low demand for power and few droughts. Now that demand is high with drought becoming more common, their technology has become limited and power shortages more frequent. Furthermore, data suggests that the use of other non-hydro energy systems helps organisations reliant on hydropower alone to enable efficiency during drought. The managers at ZESCO pointed out that they hope for a technology mix as an adaptation strategy to cope with drought when it occurs.

> *We are hoping that we can have a mix of energy so that it can be a survivability strategy for us. In the year when we do not have sufficient rains, we can depend on solar, thermal and wind energy sources.* (Interview 3T. ZESCO, 16 March 2016).

This implies to say that if ZESCO can diversify its hydropower technology to other non-hydro technology types, there can be sufficient power generation during drought episodes. Hydro power technologies requires serious diversification so as to enhance adaptive capacity. Therefore, diversification of technology as an available option for enhancing adaptive capacity can be achieved through creating thermal power technology, solar power technology and wind power technology as they do not need water to operate.

4.2.1 THERMAL POWER TECHNOLOGY

Thermal power technology is one of the alternative technologies available for diversifying hydropower technology. It has the potential to increase diversification and enhance adaptive capacity. It is flexible, as it does not need water. Data shows that it can add about 1000 MW generation capacity to the ZESCO output, the amount of power shortages in 2015/2016 in Zambia (see Table 4.3). Thermal technology using coal is appropriate and effective option readily available. Coal technology relies on heat from coal to produce energy (Zambia Development Agency (ZDA), 2014). As drought escalates and the need to diversify technology to enhance adaptive capacity increases, thermal technology is suitable to effectively respond; thus, ZESCO is investing in thermal technology. For instance, during an interview with ZNBC, the Managing Director of ZESCO mentioned thermal technology as a viable option to cope with drought. This will increase adaptive capacity because it does not require hydro (water) to generate electricity which is currently stressed due to climate variability and adds to the technology mix.

> *Coal thermal power technology is a viable technology to use because it does not require water to generate electricity, so the impacts of climate variability like drought will be lessened in the energy production.* (Managing Director 1T. ZESCO, 2016).

Similarly, during a personal interview, the Senior Manager mentioned, that coal technology can contribute substantial capacity or ability to any hydropower organisation, and help cushion hydropower shortages. For example, ZESCO commenced the installation of a coal power plant with the capacity of about 300 MW. This is important to increase generation capacity and widen a range of technology to enhance adaptive capacity to drought.

> *At ZESCO, we are practicing energy mix as it stands now. Soon we will have Maamba thermal plant coming with 300 MW on board. So, there are several projects we can talk about.* (Interview 4T: ZESCO, 16 March 2016).

Moreover, adaptation mechanisms cannot be achieved by hydropower organisations alone, but through private partnerships in the power generation sector. Therefore, according to the Managing Director, ZESCO is encouraging private partners such as EMCO and others who have come on board to invest in coal power technology:

We also have the Independent Power Producers like Maamba Collieries and EMCO. They are doing other forms of energy which is thermal technology, and they are already installing the infrastructure. For EMCO, they will be doing a 600M installation. (Managing Director 1T. ZESCO, 2016).

Owing to the fact that hydro power technology is under drought stress, thermal energy is a useful option especially with the independent power partnership (IPP) investing to lessen the cost of installation. When thermal technology is installed, an organisation tends to expand generation capacity during drought. Thus, private partners are encouraged to invest in thermal technology, as highlighted by two ZESCO Senior Managers:

For instance, we are encouraging coal technology for the people who are trying to invest in power so that we can buy energy from them. We are encouraging private partners to invest in coal power production and other renewable forms of energy other than hydro, which is under stress. We are expecting some 300 megawatts from Maamba coal plant. That is quite a significant amount of energy to be added. (Interview 1T. ZESCO, 15 March 2016).

However, data from interviews suggests that thermal technology is not environmentally friendly. It has been criticised for air pollution as a result of burning coal, which releases toxic gases into the atmosphere. Nevertheless, the manager in the environment department at ZESCO claimed that the technology to be used is modern, with less pollution;

We are also looking at coal-based generation which is not really a good investment as it relates to effects of climate change. Yet we feel that our energy is quite clean, pollution is minimal. We have a lot of coal in the Southern part of Zambia. (Interview 3T. ZESCO, 16 March 2016).

The Senior Manager revealed that although pollution is a challenge with coal power technology (IEA, 2008), ZESCO still considers it the best available option for diversification. He added that the technology will be modern, with less pollution and hence manageable:

Coal production brings mostly greenhouse gases. However, I think what is important for now is that, in Zambia, this is the first coal power plant and we can only rely on the technology that is used to reduce the amount of carbon, but we cannot eliminate it. We are hoping that the technology used will be generating less carbon dioxide than the old

> *coal power plant. We cannot completely eliminate the generation of carbon in the system. The other thing is that we have coal and we have a challenge of hydro due to drought, so coal energy is a good choice.* (Interview 1T. ZESCO, 15 March 2016).

Furthermore, the data from the respondents suggests that thermal technology, being non-hydro based, reduces the impacts of drought because climate change is becoming persistent. Considering the power shortages associated with drought, thermal technology can become a major source of power other than hydro. Thus, ZESCO will start using thermal technology as an adaptation strategy to drought because it does not require hydro. As hydropower technology is getting more susceptible to drought and costly to develop, thermal technology is able to add to the technology mix and generate power during drought because it is non-hydro hence, flexible and efficient. For example, the Senior Manager at ZESCO revealed that:

> *With hydro, we are getting to a point whereby the new sites are getting more and more expensive to develop. Cheap ones have been taken up already, so we are moving to more expensive sites. This is making thermal technology become more competitive as compared to the hydro sites which have been planned for development in future. That is also coupled with a challenge that we have now of climate change whereby you find a situation where you have drought and are not able to meet demand. In those cases, we can then we can rely on coal thermal technology to generate electricity.* (Interview 1T. ZESCO, 15 March 2016)

Having been faced with the challenges of climate change impacts such as drought, thermal technology is able to act as an alternative source of power generation other than hydro. According to the perceptions above and the data provided, thermal technology has proved to be an important prerequisite of adaptive capacity to drought because it is much more efficient to run during drought than hydro, which is becoming more expensive. Therefore, thermal technology is one of the priority technologies chosen to diversify the technology because it does not depend on water and is not affected by drought. The technology is available and evidence proves that it is a worthy undertaking to help enhance adaptive capacity to drought. The availability of thermal technologies is an indication that adaptive capacity can be strengthened.

4.2.1.1 SUITABILITY OF THERMAL POWER TECHNOLOGY

Data suggests that thermal technology is an appropriate diversification option because Zambia has significant coal deposits. The current proven coal deposits in Zambia are estimated at about

80 million tonnes (ZDA, 2014). This indicates available coal in good quantities to sustain power generation. Currently, Zambia has two coal mines – the major ones being Maamba Collieries Limited, and the Collum Coal Mine. However, despite large reserves of coal, the country has no coal fired power plants. The Manager at ZESCO confirmed in a personal interview that thermal technology is an available option for ZESCO to implement. Moreover, it was explained that the availability of coal in substantial quantities in Zambia makes coal technology an excellent choice for drought adaptation. It is likely that the technology will help combat power shortages by adding diversity to current technology and widen the mix to enhance adaptive capacity.

> *Coal is available in substantial amounts in the southern part of Zambia, so we are assured of power production all the time, even during droughts, as coal technology is non-hydro. All the efforts ZESCO is making are part of the strategy to diversify the energy mix in the country to enhance abilities to deal with drought now and in future, and generate more power to overcome power deficit challenges in the long term.* (Interview 4T. ZESCO, 17 March 2016).

Therefore, thermal technology can be important in improving diversity of technology to enhance adaptive capacity of hydropower organisation to cope with droughts. It increases the mix of technologies and reduces dependency on hydro, which is prone to drought. Thus, this can lead to widening the range of power generation options during drought, and eventually reduce power shortages. Using thermal technology is a good indication of how important diversification is in responding to drought.

4.2.2 SOLAR POWER TECHNOLOGY

With increasing attention towards diversifying technology, solar technology is receiving much attention as a potential approach to enhance adaptive capacity of organisations to cope with drought (Lewis, 2007). As the technology uses solar energy from sunlight, it adds diversity to the available technologies. Solar technology does not depend on water but instead requires sunlight, and is not affected by drought (IAPRI, 2016; ZDA, 2016).

The results found that solar power technology is available to ZESCO for diversifying its technology. Solar has the potential to increase access to a wide range of technology once it is installed. Data revealed that ZESCO is prioritising the implementation of solar power technology as a diversifying mechanism and to increase adaptive capacity and cope with drought. ZDA (2014) revealed that ZESCO's present solar power is at 0.06% and hence, negligible. Currently, ZESCO is trying to install solar power plants through Independent Power Producers (IPP) to enable smooth implementation. For example, ZESCO, in conjunction with the Zambian Government through the Ministry of Mines, Energy and Water Development (MMEWD) and IPPs, commenced the installation of solar power technology. As solar does not rely on water to generate power, it is a suitable technology for drought response (ZDA, 2014), and will achieve high adaptive capacity. This can combat power shortages which have escalated due to drought (see for example, Siliya, 2016; Mpanga et al., 2016). The MMEWD explained in an article that government is working in conjunction with ZESCO to diversify their technology by using solar power plants. The Minister added that he sees solar technology as the solution to combat hydropower shortages:

> *The government through the MEWD is putting in place diversification measures that will sustain power in the country in case we do not have enough rainfall to generate electricity next year. Energy using solar technology is coming into play*. (The Hon. Christopher Yaluma, 2015).

This implies that when solar technology is fully implemented, diversification of technology for power generation can be achieved. Solar technology is an important component of the diversification process as it contributes to enriching adaptive capacity to drought. Therefore, solar power is readily available and has the potential to offset the drought impacts that affect hydro technology.

4.2.2.1 EFFECTIVENESS OF SOLAR TECHNOLOGY

In this study, the effectiveness of solar technology entails the potential of solar power generation plants to add power to the existing capacity. It was ascertained by adding together the current and future capacity of solar power plants in Zambia.

TABLE 4.3: EXPECTED CAPACITY OF SOLAR TECHNOLOGY FROM ZESCO AND INDEPENDENT POWER PARTNERS

Developer	Current Status	Expected Capacity (MW)
Industrial Development Corporation/World Bank	commenced	600

ZESCO/ MEWD	commenced	300
Total		900

(Source, Personal Interviews, 2016)

It is evident in Table 4.3 that solar technology has the potential to effectively help diversify power generation because of its substantial capacity, which can result in high adaptive capacity. This also implies that solar technology offers organisations an attractive adaptation option for drought. Therefore, in the event of drought, solar technology can supply the necessary generation to avoid power shortages. For example, the ZESCO Managing Director, in an interview with ZNBC, stated that ZESCO will be installing a solar power plant with the production capacity of about 300 MW:

> *ZESCO in partnership with MEWD, is about to bring on board 300 MW of solar power into the grid, which will increase power production capacity*. (ZESCO Managing Director, 2016).

Similarly, during a personal interview with a Senior Manager at ZESCO, it was stated that solar technology is an important option for ZESCO that will add variety to its current technology and expand the generation capacity required to diversify technology and enhance adaptive capacity:

> *We are investing in solar, not as ZESCO alone but as a country, through various independent stakeholders. We expect 100 megawatts of solar this year (2016) as we try to produce 300 MW. Towards the end of the year, we hope our colleagues in the Industrial Development Corporation (IDC) will be able to bring up 100 megawatts of power out of the targeted 600 MW, we are trying to start with Lusaka South Multi-Facility Economic Zone.* (Interview 1S. ZESCO, 15 March 2016).

This is an indication that once solar technology is available, it can be a prominent and serious mechanism which hydropower organisations can use to diversify power generation technology during drought and help increase adaptive capacity. Besides hydro technology, solar technology is an important prerequisite for effective adaptive capacity too drought. Furthermore, the Minister of MEWD in Zambia mentioned in his statement that IPPs and ZESCO are already in the process of laying out solar technology for about 600 MW, to help increase the technology diversification mix. This is meant to widen access to various power energy sources and increase power generation capacity in order to adapt to drought:

> *Government is in the process of evaluating bids for the development of 300 MW solar power plants across the country. Additionally, government is procuring 600 MW of solar power through the Industrial Development Corporation (IDC). Two plants of 50MW each constitute Round 1 of the 600 MW programme. Currently, the IDC is in the process of selecting the winning bidder (IPP) via a Request for Proposal (RFP) in a transparent and competitive bidding process – and the bidder with the lowest tariff will eventually win the bid to build the solar plants.* (Siliya, 2016).

In an interview with Reuters, The Director General of the ZDA also mentioned that other IPPs have commenced the installation of solar power technologies at different places in the country. For example, Zambia's Industrial Development Corporation (IDC) recently partnered with the World Bank in a programme called "Scaling-up Solar", where they intend to install a 600 MW solar power plant. Solar technology is a good option and an indication of increasing adaptive capacity because it is not affected by drought. This also suggests that solar technology, being an available adaptation option, has the potential to add power generation capacity and widen the technology mix, rather than depending on hydro only. The total solar energy production is expected to reach 6000 MW in the near future, as stated by the Director General of ZDA in an interview:

> *The totality of all this should help us to ramp up our production of power to the level that we need to get to which is ultimately about 6,000 megawatts.* (Director General of the ZDA, 2016)

While solar technology is a suitable and available adaptation option for diversification, it is by far the least widespread and under-developed technology in Zambia and other Southern Africa countries. There is need for more aggressive prioritisation of this technology to boost technology diversification as climate change becomes more challenging and drought becoming more prevalent. Despite the great climatic solar resource in Zambia, the installed solar power technology capacity is negligible (Zambia Development Agency (ZDA), 2014). In addition, speaking in an interview with journalists from Reuters, the ZDA Director General also mentioned that:

> *Zambia expects to triple power output to 6,000 megawatts (MW) by 2018 through the expansion of solar energy. For example, a group of IPPs from Italy were looking to set up a solar plant in the Lusaka South Multi-Facility Economic Zone and two others in the Western and North-Western provinces. This suggests that there is high potential for*

solar power technology, which will strengthen diversification and the ability to adapt and cope with drought. Added to that, power generation from hydro technology has dropped due to low water levels in the previous seasons in the Kafue River Basin, forcing ZESCO to implement load shedding and reduce production capacity. However, this has been a wake-up call for ZESCO. This drought situation has taught us that we need to diversify our sources of energy to solar instead of relying on hydro, which in turn relies on a good rainfall every year. (Director General, Zambia Development Agency, 2016).

The perceptions of the Director General indicated that solar power technology is a priority for diversifying technology in Zambia. It will contribute to increasing the mix of energy sources for ZESCO and result in enhancing adaptive capacity to drought.

4.2.2.2 SUITABILITY OF SOLAR TECHNOLOGY

For the purpose of this research, appropriateness of technology involves suitability of environment for its implementation in order to determine its viability. Solar technology needs to have a suitable source of raw material to use for power generation. In this case, sunshine energy must be available to make this technology appropriate to install and rely on. Thus, the appropriateness of solar technology is important in determining adaptive capacity. The average daily solar insolation in units of kWh/m2 per day is known as "peak sun hours". The term "peak sun hours" refers to the solar insolation a particular location would receive if the sun shines at its maximum for a certain number of hours. As peak solar radiation is 1 kW/m2, the number of peak sun hours is identical to the average daily solar insolation. For example, a place that receives 8 kWh/m2 per day can also be said to have received 8 hours of sun per day at 1 kW/m2 (International Energy Agency (IEA) (2008). In this regard, the data shows that Zambia has an average of approximately 2000 – 3000 hours of available sunshine annually, as shown in Figure 4.3. Therefore, solar energy is abundant and can provide high potential for the use of solar power technology in Zambia. The abundance of solar energy is a good indicator for the installation of solar technology appropriate for ZESCO. An average potential energy output per unit area (solar radiation) is about 5.5 kWh/m^2/day. Lusaka province has the highest irradiation, at 8 kWh/m2/day. Data from the Renewable Energy Corporation Programme (RECP) (2015), shows that generally the northern region recorded the highest solar irradiation of about 2300 kWh/m2/year, as shown in Figure 4.1 below.

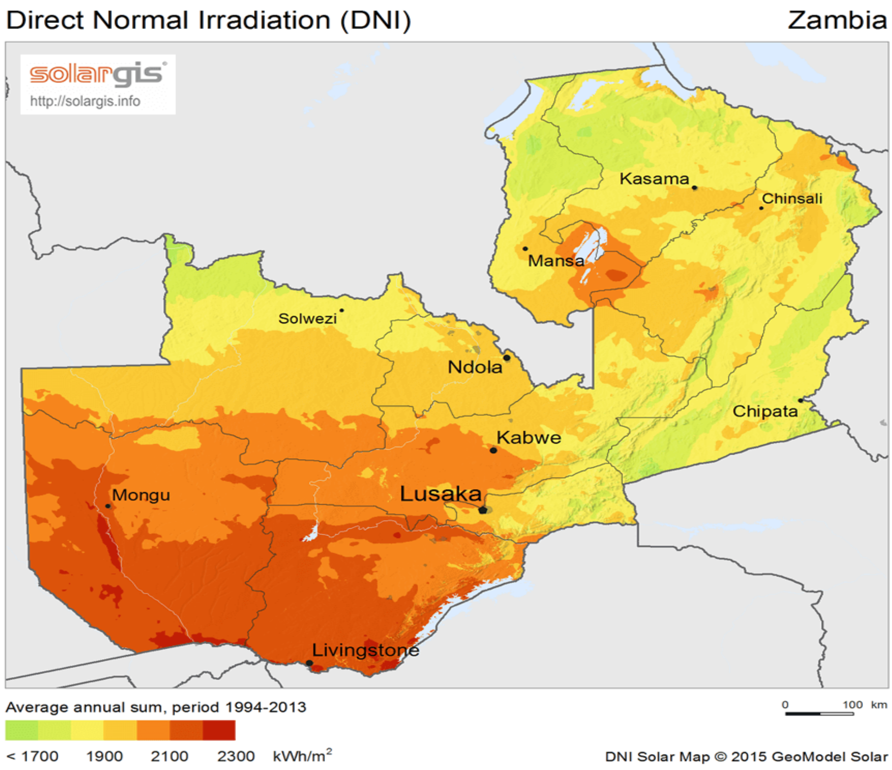

FIGURE 4.1: DISTRIBUTION OF AVAILABLE SUNSHINE IN ZAMBIA

(Source: RECP, 2015)

It is evident in Figure 4.1 that solar power technology can be suitably implemented as an adaptation option to add diversity to current technology. It has the ability to increase the energy mix as a response mechanism to drought, and results in high adaptive capacity because the sunshine is readily available. Thus, during periods of drought, solar technology has the potential to complement power generation. Furthermore, sunlight being a renewable source of energy, it is clean and environmentally friendly. However, the use of solar technology has remained relatively low in Zambia because of high initial cost and high reliance on hydro technology (ZDA, 2014).

Solar power has the potential to enhance adaptive capacity and reduce dependence on hydro. It can enable hydropower organisations to lessen power deficit and increase the technology mix. Furthermore, compared with others, solar technology is clean energy produced without pollution. It is smart, efficient and sustainable. It ultimately depends on the sun energy to generate power and not water. As a result, it is not affected by drought

4.2.3 WIND POWER TECHNOLOGY

Wind-generated power technology is one of the most important future energy sources, having the attractive attribute that the fuel is free. Wind technology interest lies in the fact that energy can be extracted from wind resources, usually expressed as wind speed. Wind technology can ensure greater independence from hydropower technology (IEA, 2008). The study results suggest that wind technology has the potential to diversify technology which in turn can increase the technology mix and enhance adaptive capacity to cope with the drought. It is evident that wind power has significant potential to complement hydropower generation when hydro technology is affected by drought. Wind technology is not only available as a diversification option and a condition for adaptive capacity, but it does not depend on hydro. Wind technology will enable ZESCO to increase its range of access to alternative power sources other than hydro, hence enhancing diversification of power generation technology. As a result, its adaptive capacity will be enhanced as a way of responding to drought. In addition, the technology is available, appropriate and effective. In an interview with ZNBC, the Managing Director of ZESCO mentioned that wind energy has a potential to add about 1000 MW of power in Zambia, hence a substantial platform for technology diversification:

> *We are also looking at wind. It has been said in the past that there may not be so much wind power in the country. However, further studies have shown that we can get as much as a 1000 MW. There are companies that have come on board working with ZESCO in trying to come up with feasibility studies in ensuring that we could develop these forms of energy such as wind. There has not been any major addition to the country's generation capacity in the last 20 – 30 years, despite a growing demand for power over recent years. So, wind energy technology is an option we opt for to improve power generation capacity* (Managing Director 1W. ZESCO, 2016).

In the above statement, it is pointed out that wind has been identified as one of the most probable and promising conditions necessary for diversifying technology, following the need to reduce dependence on hydro technology due to drought. As wind is available, ZESCO is aware of the fact that wind technology can have an advantage over hydro power technology during drought, because it is non-hydro dependent. It can also be feasible for mechanical use, especially on the farmlands.

4.2.3.1 SUITABILITY OF WIND POWER TECHNOLOGY

The suitability of wind technology implementation involves its appropriateness to the suggested environment. Wind technology requires suitable wind speeds for power generation, must be conducive to appropriate installation, and its supply must be dependable (IEA, 2008). Thus, in gauging the appropriateness of wind power technology, it is important for ZESCO to determine the adaptive capacity by knowing the expected capacity. Data shows that favourable wind speeds exist in Zambia to generate off-grid wind power.

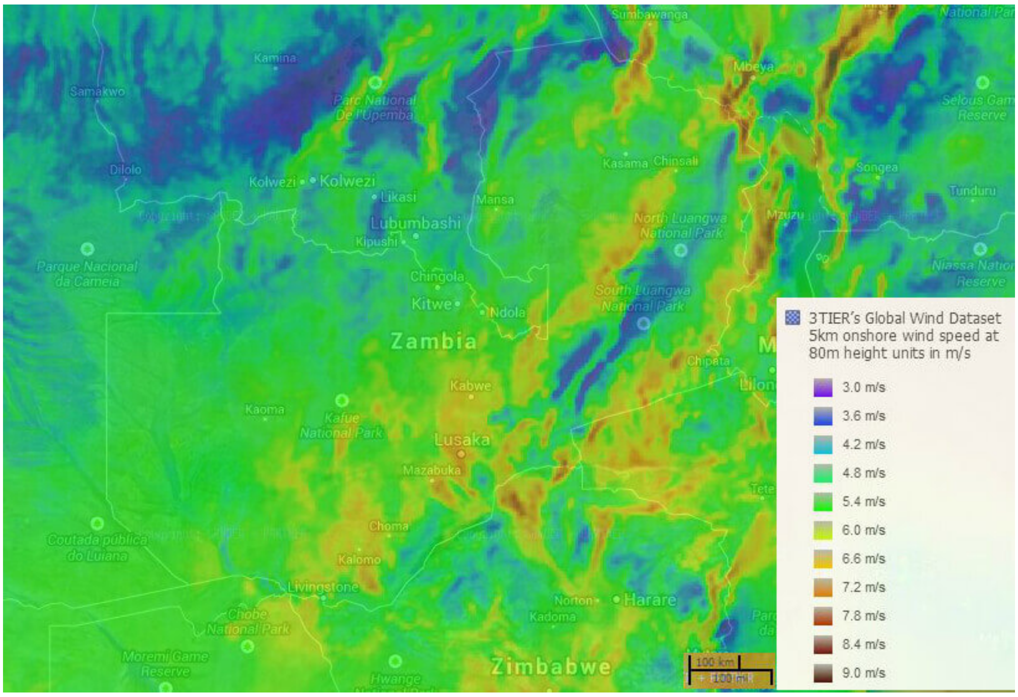

FIGURE 4.2: WIND SPEEDS IN ZAMBIA

(Source: RECP, 2015)

Figure 4.2 shows that the potential for wind power technology is relatively low in most areas although advanced feasibility assessments have not been adequately conducted. Wind data indicate speeds of between 0.1 and 3.5 meters per second, with an annual average of 2.5m/s, while the rated speeds for power generation is 15 – 19m/s. These wind speeds are not particularly suitable for electricity generation, but are mainly for mechanical applications such as water pumping and irrigation. This implies that wind technology can promote technology diversification and enhance adaptive capacity to drought. Furthermore, the MMEWD mentioned during a statement in parliament that there are some specific areas in Zambia's Western Province where wind speeds are thought to be as high as 6 m/s, similar to the conclusion made by the RECP (2015).

> *Satellite models have revealed that Zambia has the potential for wind speeds of more than 5 meters per second in North-Western and Northern parts of the country, to support power generation. In addition, the Ministry is currently with the help of the World Bank developing a National Renewable Energy Resource map focusing on solar and wind. This map will provide government and private investors with information on the country's resource potential to guide investments on suitable locations and the quantities of renewable resources available in Zambia. The activity will be completed in 2017.* (Siliya, 2016).

This statement clearly shows that wind power technology is considered viable to contribute to diversifying the available technology so as to lessen the dependence on hydro technology to generate power. Once wind power technology is made available, it is able to subsequently promote adaptive capacity to drought, which in turn can help reduce power shortages. However, the main environmental concerns are visual impact, noise, and the risk of bird collisions as well as wildlife disruption, which are easily dealt with (IEA, 2008).Therefore, based on the above findings, wind power technology as an option for enhancing adaptive capacity has great potential to contribute to the technology diversification of hydropower organisations, in turn helping overcome the drought impacts facing hydropower technology. In addition, hydropower organisations must consider wind power technology as an important component of technology diversification in order to broaden the range of technologies and enhance adaptive capacity to drought. Moreover, wind is environmentally sound and is one of the available options ZESCO is using to diversify its technology. Therefore, wind technology can be an effective prerequisite for adaptive capacity to drought and has the potential to create the necessary conditions for improving technological diversity.

4.3 CAPACITY OF TECHNOLOGY

The study revealed that the generation capacity of (power plants) is a major prerequisite for the adaptive capacity of hydropower organisations to cope with drought. Capacity implies the amount of power generation from the power plants measured in megawatts. The capacity of technologies determines power generation capacity, which in turn strengthens the conditions necessary for enhancing adaptive capacity. When the capacity of power plants is expanded, the capacity to generate power during drought can be expanded with minimal power shortages, enhancing coping abilities. However, although power demand and economic growth in Zambia have expanded in recent years, there has not been a major expansion in technology (Mpanga et al., 2016; IAPRI, 2016). While drought escalates shortages of hydropower, limited technology seems to constrain the generation capacity of hydropower systems. Eventually, power deficits reflect low adaptive capacity to drought in organisations with limited technology. Data shows that ZESCO is putting in place adaptation measures to cope with drought. It is developing new and old technologies to strengthen its coping ability (World Food Programme (WFP), 2015; IAPRI, 2016). In view of this, ZESCO is enhancing adaptive capacity by increasing their technologies.

4.3.1 ZESCO'S POWER GENERATION CAPACITY AND POWER DEFICIT

For example, data shows that there was a power deficit of about 1000 MW between 2015 and 2016 in Zambia, due to drought and limited technology. Even though Zambia has a potential hydropower capacity of about 6 000 MW, ZESCO's installed generation capacity is about 2 300 MW, leaving the balance unexploited, as shown in Table 4.4 (ZDA, 2013).

TABLE 4.4: ZESCO'S INSTALLED HYDROPOWER GENERATION CAPACITY AND POWER DEFICIT IN 2015/2016

Technologies (Power Plant)	**Potential Generation Capacity (MW)**	**Installed Capacity (MW)**	**Amount Generated (MW) before 2015**	**Amount Generated (MW) in 2016**	**Approximate Shortage (MW)**
Kafue Gorge Upper Power plant		990	650	540	
Kariba North Bank		1080	320	275	
Victoria Falls		108	55	91	
Itezhi-Tezhi Power plant		120	60	30	
Lunsemfwa		56	14	14	
Total	6000	2234	1015	963	1000

(Sources: Personal Interviews, 2016; Mpanga et al., 2016; ZDA, 2013)

It is evident in Table 4.4 that ZESCO fails to harness the 6000 MW generation potential due to limited technology. Although the installed generation capacity is around 2300 MW, major technologies operate below normal capacity most likely as a result of drought, hence the power deficit. As hydropower organisations including ZESCO depend on water to generate power, drought is causing mounting pressure on river basins. This contributes to low power generation leading to power deficits. (World Bank, 2015). ZESCO has been generating slightly over 1000 MW below its installed capacity, the amount of its power deficit. This contributed to the current 2015/2016 power shortages, mainly because of limited technology which lacks adequate capacity to cope with drought. Therefore, data suggests that the growing shortfall of hydropower generation is exacerbated by drought to which technology amount is small. This is similar to the conclusions reached in other studies (see for example Muzeya 2015; ZIPAR, 2015; IPRI, 2016; Mpanga, et al., 2016). In fact, in 2016, the Minister of Energy and Water Development informed parliament in a statement that the country has a power deficit of about 1000 MW due to its dependency on hydro.

> *From 2015, Zambia has been experiencing power deficits due to low rainfall experienced during the 2014/2015 rainy season that caused drought. The deficit stood at 560 MW in June 2015 and currently stands at about 1000 MW in 2016. This is mainly because 9 % of Zambia's electricity production is hydro-based with very limited technology and infrastructure. Arising from the deficit, load shedding was started in order to preserve water in the dams and avoid a complete shutdown of the generating plants.* (Siliya, 2016).

Both the research and the perceptions of respondents have pointed out that the development of existing technologies is an important factor that any hydropower organisation need to consider. It is a prerequisite for adaptive capacity to drought. As such, limited technology can constrain hydropower organisations in generating sufficient power and make them vulnerable to the effects of climate change, particularly drought. Moreover, as ZESCO indeed lacks the technology to counter drought impacts, in its quest to respond to drought, the company has identified technology as one of the priority mechanisms that needs improvement. In this regard, it identifies two major components for improving its technology: the construction of new power plants and the expansion of already existing power plants. Once the technology is enhanced, it can help improve adaptive capacity to drought.

4.3.2 CONSTRUCTION OF NEW TECHNOLOGIES

The study results suggest that the construction of new power plants can increase the capacity of available technology for power generation. The construction of new technology has been identified as one of the ways to expand technology which in turn can improve adaptive capacity to drought. In Zambia there is limited technology to generate sufficient power to cope with drought. This situation, among other factors, contributes to power deficits and exacerbates power outages. As such, to enhance the ability to cope, data indicates that hydropower organisations must prioritise the construction of new technologies (power plants) in order to increase generation capacity and amplify adaptive capacity to drought. ZESCO's installed generation capacity has been static and limited for a long time. As shown earlier, ZESCO's installed capacity of 2300 out of a possible 6000 MW is already limited. Besides drought, the initial capacity of the hydro power plants (HPP) was meant to generate electricity for Zambia's smaller population and economy between the 1970s and 1990s. However, population and economic growth have advanced, while technology development has remained stagnant, thus contributing to the power deficit (Yamba et al., 2011; Word Bank, 2015). However, ZESCO attempting to increase the capacity of its hydropower technologies as one of the available coping options. In fact, the Senior Manager at ZESCO revealed that although the current hydropower technologies are still intact and under normal operation, power generation capacity to meet the demand is limited, especially during drought periods such as the 2014-2016 drought,

> *Our technology/infrastructure, despite being built a long time ago, is still intact and operating well because we maintain it. But, I think the challenge is that we have not been adding more capacity in terms of power plants. We are now building more new power plants because demand has gone up and we have only maintained the same old power plants. The technology itself is working well but it is very limited as demand continues to go up and droughts are becoming more common.* (Interview 1I. ZESCO, 15 March 2016).

According to the manger's perceptions, it is clear that when technology is limited, hydropower organisations struggle to achieve the required adaptive capacity to cope with drought. On the other hand, if the technology is sufficient, an organisation is perceived to be able to generate enough power during drought periods. The biggest technology challenge of hydropower organisations is that they have been reluctant to construct and install new power plants in order to add generation capacity and increase technology, which is an important prerequisite of adaptive capacity. Thus, this poses huge technological limitations and arrests adaptive capacity to cope with drought. For example, in a personal interview with a manager at ZESCO, it was noted that if the expansion of technology had been done earlier, before 2010, and following the initial plan, drought-associated power shortages would not have taken place. Despite plans for technology expansion being overdue at the time, nothing had been done.

Ten years into my work, we started seeing that we were likely to go into energy deficit if we did not invest. We made presentations, and there was nothing on the ground. It is only now that we are commissioning projects such as Kariba North extension, Itezhi-Tezhi, Kafue Lower Gorge, and others. If it was 10 years ago, we would not be where we are today, with limited technology and power shortages. (ZESCO interview 3I, 16 March 2016).

Therefore, if the construction of new plants can be implemented early, it means that technology can be increased. This implies that there are conditions for necessitating adaptive capacity to respond to drought. Owing to this, ZESCO commenced some new construction projects for the purpose of expanding its technology, as seen in Table 4.5 below.

TABLE 4.5: CAPACITY OF NEW AND EXPANDED POWER PLANT PROJECTS

Power Plant	**Capacity (MW)**	**Expected Completion Time**
Rehabilitation and Expansion of the Musonda Falls Power Plant	5	2015
Upgrading of the Lunzua power plant	15	2015
Kabombo Hydro Power Plant	40	
Ndola Energy Company thermal power project	60	
Kariba North Bank Expansion project	80	
Itezhi-Tezhi Power Plant project	120	2015
Kalungwishi power plant	247	
Mamba Thermal Power Plant Project	300	2016
EMCO Energy, coal power project	600	2017
Kafue Gorge Lower Hydro Power project	750	2019/2020
Shiwang'andu mini-hydro power station project.		
Kariba North Bank extension	1200	
Batoka Gorge hydro power plant	2400	2022

(Sources: ERB, 2014; Personal Interviews, 2016; IAPRI, 2016; Mpanga et al., 2016)

The table shows that there are both large and small capacity plants under construction, with over 5000 MW capacity of power generation. This data indicate that the construction of new power plants can influence technology advancements, which also enhances adaptive capacity. Increasing technology capacity by constructing new power plants is part of adaptation strategies to cope with drought. In this regard therefore, , ZESCO is constructing small and large scale power plants, hydro and non-hydro based technologies. The new power plants are expected to contribute to generation capacity and lessen pressure on the existing limited technology. This can help generate sufficient power to enhance adaptive capacity. Construction of the new Kafue Gorge Lower power plant (KGLPP) downstream of the Kafue River is part of a large-scale development which will have a capacity of 750 MW. It is a long-term, four-year drought adaptation project and will increase ZESCO's generation capacity and help to combat power shortages and increase adaptive capacity. As mentioned by ZESCO Managing Director in an interview with ZNBC, by constructing new power plants, ZESCO will have the added capacity to reduce power shortages.

> *Going forward in the long term, we have embarked on a project that has been on the drawing board for a very long time. This is the Kafue Gorge Lower power plant. Zambia is endowed with a lot of hydro and if this hydro is harnessed, the power crisis would be managed. The Kafue Gorge Lower power plant will give us 750 MW when it is completed by the year 2020. We are very confident that in the long run, the much talked about and awaited KGLPP will be operational.* (Managing Director 1T. ZESCO, 2016).

The Senior Manager at ZESCO also mentioned that when the KGLPP is complete in 2020, drought-associated power shortages will highly be minimised. The construction of new plants increases the capacity to generate power. As a result, the adaptive capacity to cope with drought is increased as follows:

Our projection is that drought problems will end soon after an increase in generation capcity of ZESCO. For example, assuming that we experience erratic rainfall in the next four years, we would rely on. Kafue Gorge Lower Project (Interview 1I. ZESCO, 15 March 2016).

Not only will the Kafue Gorge Upper Power Plant (KGUPP) project increase ZESCO'S adaptive capacity, it will also improve water security by enhancing water use efficiency in the Kafue River Basin. The Manager also revealed that water from the ITT reservoir will be used to generate hydropower at 3 stations along the Kafue River (i.e. ITTPP, KGUPP and KGLPP) to achieve maximum benefits even when there is low water levels (drought) in the KRB hence efficiency.

If you look at our Kafue river system, we have a casket of stations i.e. Itezhi-Tezhi, Kafue Gorge Lower and Upper. If these three were implemented, even when we have low water levels in the reservoirs, they will still generate. First it generates at Itezhi-Tezhi, Kafue Gorge Upper and finally Kafue Gorge Lower. We have been a bit wasteful. Itezhi-Tezhi was just releasing water without realising maximum generation benefits out of it. And Kafue Gorge Upper was just releasing water into the Zambezi River without making any use of it. But once the three power stations are developed, we will be using the water much more efficiently so that even when drought comes, we will still be getting much power from the available little water. Efficiency is vital in adaptive capacity measures. Hence, we will be getting more from the same water and maximise production. (Interview 3I, ZESCO, 16 March 2016).

Additionally, the Managing Director of ZESCO, in an interview with ZNBC, the Managing Director of ZESCO revealed that another large-scale project called Batoka Gorge Power Plant is underway as an adaptation strategy to drought, and is aimed at enhancing power generation capacity. It is expected to add 2400 MW which will substantially in increase capacity and the potential to cope with drought.

> *Apart from that, we are also doing the Batoka Gorge. The Batoka Gorge is 2400 MW, with 1200 MW on either side of the Zambezi River. These projects are commencing in 2016. If we did most of the activities we are talking about, in the long run, this crisis would not be before us''* (Managing Director 1T. ZESCO, 2016).

In Table 4.6, non-hydro technologies were also included to demonstrate that the construction of non-hydropower plants plays a huge role in contributing to the expansion of technology and consequently to adaptive capacity. Non-hydro technologies are not affected by drought as explained earlier, and are hence good options for drought adaptation. The 300 MW Maamba thermal power plant is over 80% complete and will soon be operational. The small hydro power plants that are being upgraded and expanded, such as Kalungwishi, Musonda and Lunzua Hydro, will also play a significant role in adding technological capacity. They are being upgraded and expanded. In addition, data revealed that planned investments in 600 MW solar power plants and wind are underway. Therefore, by 2025, all projects are expected to contribute a total generation capacity of about 4,500 MW (IAPRI, 2016). This reflects a huge and substantial effect on increasing technology. In fact, the 1000 MW power shortfall of 2015/2016 would have been avoided if the expected margin had been available at that time.

Therefore, it can be clearly noted from the views and perceptions of respondents that the construction of new power plants is one of the most important ways of expanding technology. As the technology acts as a prerequisite for enhancing adaptive capacity to drought, increasing it will improve the conditions necessary to respond and adapt. Technology is significant in determining the adaptive capacity of hydropower organisations because it determines how much power should be generated and made available during times of drought. Technology plays a role in ensuring that there is constant and enough generation of power, and this is being achieved through the construction new power plants. Once the construction of these power plants is complete, ZESCO will have the reinforced reinforcements necessary to respond efficiently to drought.

4.3.3 EXPANSION OF THE CAPACITY OF THE EXISTING TECHNOLOGIES

Results of the study suggest that expanding the capacity of the existing technologies have a positive impact on creating prerequisites for enhancing adaptive capacity. The increase in the capacity of power plants is equivalent to the amount of power being generated. Therefore, this can help generate more power during drought. Therefore, in light of power shortages coupled with growing demand (see for example, Mpanga et. al., 2016; IAPRI, 2016), ZESCO is investing in technology expansion projects to increase the capacity of the existing power generation capacity. In addition, ZESCO is rehabilitating, upgrading and expanding the capacity of its existing technology in both its large and small power plants in order to increase the capacity of its hydropower generation, which has been limited for a very long time (ZESCO, 2014). For example, as explained earlier, large projects such as the expansion of the Itezhi-Tezhi HPP are of huge significance in adding capacity and enhancing adaptive capacity. The upgrading of the KGUPP and Kariba North Bank plants are also important in increasing hydropower generation efficiency and enhancing adaptive capacity. Further projects to expand and upgrade small hydropower plants include the rehabilitation and expansion of the Musonda Falls HPP, upgrading of the Lunzua HPP, and several others. Therefore, it is vital to note that increasing the generation capacity can be an essential mechanism for responding to drought. As climate change is likely to increase (Tir & Stinnett, 2012; IPCC, 2007; Honkonen, 2016) ZESCO must commence to rehabilitate, upgrade and expand the capacity of its existing technology (both large and small sized power plants) in order to enhance the prerequisite required to cope and adapt with drought.

4.4 LOCATION OF TECHNOLOGIES

Results of the study found that varying the location of power plants can be an important prerequisite for enhancing adaptive capacity of organisations to cope with the effects of climate change particularly drought. (IEA, 2008). Therefore, different technology locations have potential to provide high adaptive capacity to drought.

4.4.1 HOW VARYING THE OF LOCATION OF TECHNOLOGIES CREATES PREREQUISITES FOR ADAPTIVE CAPACITY

The study showed that variations in the location of technology is important in creating the necessary conditions and mechanisms to respond to drought, hence improving the adaptive capacity of hydropower organisations. To this end, ZESCO has identified location as a component that can be used to provide the necessary conditions for adaptive capacity. Varying the location of power plants in different river basins, together with their technologies, can influence potential power generation, depending on the geographical position of the river basin, thus determining the effects of climate change stresses on power generation. For example, data shows that Zambia has two main river basins – the Zambezi River Basin (ZRB) which houses the Kafue River Basin (KRB) in the south, and the Congo River Basin (CRB) in the north, where the Luapula River Basin (LRB) is located, as shown in Figure 4.3. (Wamulume et al. 2011; Yamba et al., 2011; World Bank, 2014). These two river basins have different climatic conditions.

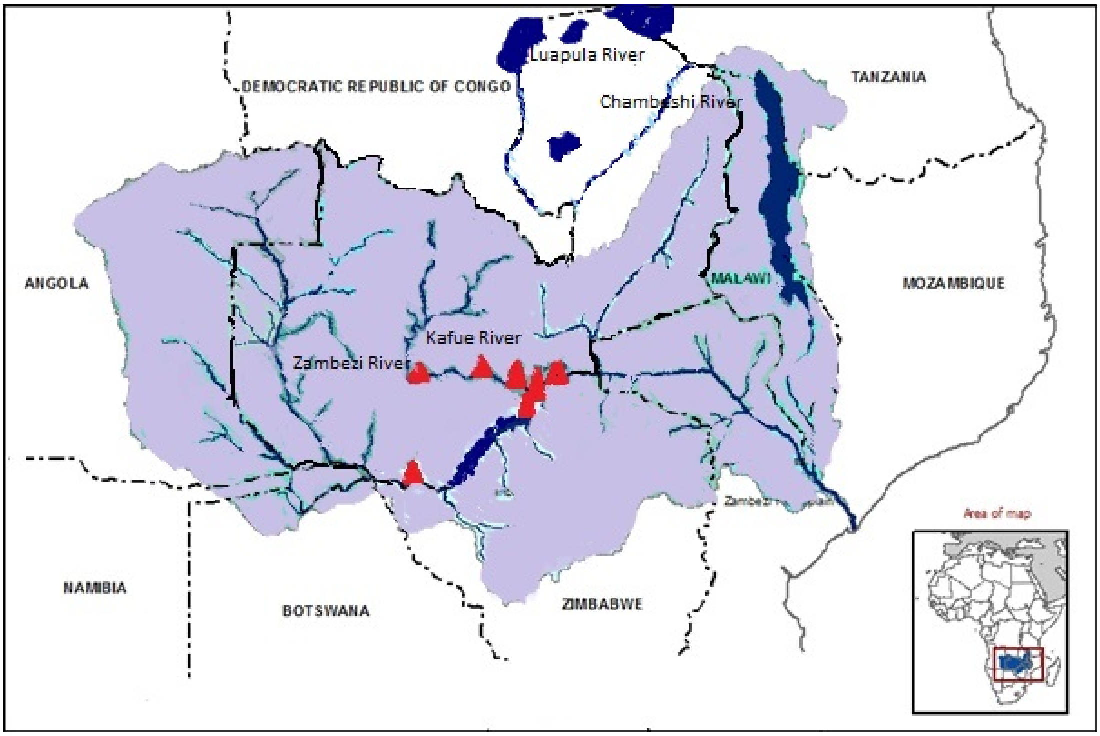

FIGURE 4.3: THE ZAMBEZI RIVER BASIN AND LOCATION OF ZESCO HYDROPOWER PLANTS

(Sources: Yamba et al., 2011; World Bank, 2014)

It is evident on the map in Figure 4.3 depicting both existing and proposed hydropower technologies that the ZESCO's major hydropower plants are located in the Zambezi River Basin and its sub- catchment, the Kafue River Basin, which is believed to be more prone to drought than the Congo River Basin and its sub-catchment, the Luapula River Basin in the northern part of Zambia. This is as a result of the adequate water availability for hydropower generation. However, as drought is becoming persistent, existing technologies in the KRB are being constrained due to lack of variation of location of technology, as shown in the map. For example, the manager at ZESCO revealed in a personal interview that lack of variation in the location of power plants is contributing to the problem of power shortages because most of the major power plants are located in one basin and as a result, are affected by drought at the same time. Moreover, weather conditions, particularly rainfall, has the same pattern since it's the same river basin. It is also perceived that the KRB experiences more droughts than the LRB yet it is the location of almost all major power plants.

> *The country has two major basins, namely the Zambezi River Basin in the south and the Congo River Basin in the north. The Congo River Basin is less prone to drought conditions whereas the Zambezi River Basin is more prone. Unfortunately, most of our generation capacity is located in the Zambezi River Basin and has been developed there. A very small number of hydropower stations have been developed in the Congo River Basin yet it is less vulnerable to drought occurrences.* (Interview 3L. ZESCO, 16 March 2016).

Consequently, this largely constrains hydropower generation in the KRB and contributes to power shortages, more especially during drought. One of the major challenges of hydropower organisations is that they lack variation in the location of hydropower technologies in other river basins that are less prone to drought. As such, adaptive capacity to drought is constrained.

The study results suggested that the risk of climate change such as drought can be evenly distributed and minimised provided the location of the technology is in different river basins to create the needed conditions for increasing adaptive capacity. However, when technologies are concentrated in one area, as is the case with ZESCO in the KRB, the drought impacts are larger and negatively affect the power generation of hydro power organisations to cope and adapt. This study proposes that variation in location of the technology can result in high adaptive capacity because of the heterogeneity of the river basin climates.

TABLE 4.6: MAJOR EXISTING AND ONGOING HYDROPOWER PLANTS IN THE ZAMBEZI RIVER BASIN

Name of the Power Plant	Capacity	Location
Itezhi-tezhi	120	Kafue River
Kafue Gorge Upper	990	Kafue River
Kafue Gorge Lower	750	Kafue river
Victoria Falls	108	Zambezi River
Kariba North Bank	720	Zambezi River
Kariba North Bank Extension	360	Zambezi River
Batoka Gorge		Zambezi River

(Sources: Yamba, 2011; World Bank 2014 Personal interview, 2016)

Table 4.6 shows that ZESCO's generation technology is all located in the same basin. This means that the climatic conditions do not vary and as such, the drought effects are severe. When drought occurs in the basin, it certainly lowers the hydropower generation of all the power plants. For example, the Kafue River consists of the KGUPP with about half of Zambia's total hydropower production, the Itezhi-Tezhi Hydro Power Plant on the upper stream, and the new Kafue Gorge Lower Power Station that is scheduled for commission in 2020.The Zambezi River consist of the Kariba North Bank, the Batoka and the Victoria Falls HPP (Yamba et al, 2011; ZESCO, 2012). We have seen that when the major technologies are located in one basin, drought affects them in the same way and at the same time, thus, coping ability is largely constrained. In the same vein, although the location of major hydropower technologies is in the ZRB and its sub-catchment the KRB, they are more susceptible to drought than the Congo River Basin and its sub-catchment, the Luapula River Basin. Data from the ZESCO interviews indicates that the Luapula River is becoming a priority location for the construction of new hydropower technologies because it is less prone to drought than the ZRB and its sub-catchment, the KRB. The Luapula River is part of the CRB in the Equatorial region (see Figure 4.4). It consists of perennial rains thus, making it a more suitable location for hydropower technology. The Congo River Basin gets water from the equatorial region of the Democratic Republic of Congo, which receives perennial rainfall, making the Luapula River less susceptible to drought. The Zambezi River Basin and its sub-catchment, the Kafue River Basin, on the other hand receives annual rainfall (Yamba et al., 2011). As a result, the KRB experiences more drought than the LRB.

ZESCO's move to start construction of new power plants in river basins other than the KRB is going to positively impact its hydropower generation. In so doing, drought can be offset because the different climatic conditions of different river basins will not respond to drought in the same way. Hence, the location of power plants and technology plays a significant role in ensuring that the power plants respond differently to their different climatic conditions, helping hydropower organisations to enhance their adaptive capacity.

4.4.2 LOCATION OF HYDROPOWER TECHNOLOGY IN AGRO-ECOLOGICAL ZONES

Data shows that Zambia consists of three major agro-ecological zones, with rainfall being their main distinguishing factor, with Zones I, II and III shown in Figure 4.4. According to Phiri et al., (2013), agro-ecological zones refer to areas that are characterised by similarities chiefly in terms of their rainfall, average temperatures, soil types and farming systems, and their socio-economic parameters. For purposes of this study, rainfall was made the core parameter classifying eco-regions because it is influenced by and is used as indicators of climate change, and determines the generation if hydropower technologies. Each zone has distinct features of rainfall amounts and patterns (Thurlow et al., 2012; Phiri et al., 2013; Funder et al., 2013).

FIGURE 4.4: ECOLOGICAL ZONES OF ZAMBIA AND SUITABILITY FOR HYDROPOWER TECHNOLOGIES

(Sources: Jain, 2007; Thurlow, 2012; Funder et al., 2013)

The above map in Figure 4.4 shows that Zone I lies in the western, southern and partly eastern part of the country. It receives less than 800mm of average rainfall annually. For the past 20 years it has experienced low, unpredictable and poorly distributed rainfall as a result of climate change. The meteorological data, according to Phiri et al., (2013), suggests that it is currently the driest zone and most prone to drought. However, it houses some major hydropower technology. Zone II covers the central part of Zambia, extending from the east through to the west. It receives an average rainfall of about 800 to 1000mm annually (Jain, 2007; Phiri et al., 2013). It also houses major hydropower technologies (see also Table 4.7). Zone III spans the northern part of the country. It receives over 1000mm rainfall annually (Phiri et al., 2013; Thurlow et al., 2012; Jain, 2007; Funder et al., 2013). The high rainfall in this region results in the availability of water and hence has potential to generate hydropower, and is suitable for locating new hydropower plants. However, despite being a suitable environment for hydropower generation, none of ZESCO's major power plants are located in this region (ZESCO, 2014). Thus, this contributes to low adaptive capacity to drought. The location of major hydropower plants is concentrated in Zambia's drought prone zones.

TABLE 4.7: ECOLOGICAL ZONES, FEATURES AND EXISTING MAJOR HYDROPOWER PLANTS

Main Agro-Ecological Zone Features				
Agro-Ecological Zone	**Average Annual Rainfall**	**Existing and Planned Hydropower Plants**	**Geographical Location**	**Basin**
Zone I	Below 800 mm	Victoria falls HPP, Kariba North Bank HPP, Kariba North Bank extension HPP, Batoka HPP Small-Hydro	Southern, and western parts of eastern Zambia following the Zambezi-Luangwa valleys	Zambezi River Basin

Zone IIa and IIb	Between 800-1000 mm	Itezhi-tezhi HPP, Kafue Gorge Upper HPP, Kafue Gorge Lower HPP, Small-hydro,	Northern tip of Region-I, running down across the western parts of the central region of Zambia and south-westwards, covering parts of the western province	Zambezi River Basin and its sub-basin, the Kafue River Basin
Zone III	Above 1000 mm	Small hydro's	Bordering the Congo areas; northern Luapula, the Copperbelt, and north-western provinces of the country	Congo River Basin and its sub-basin. Luapula and Chambeshi River Basins

(Sources: Phiri et al., 2013; Personal interview, 2016)

It is evident in Table 4.7 that despite Zone I receiving the lowest rainfall and being the driest and most prone to drought in the ZRB, it houses major hydropower plants such as the Kariba North Bank, Batoka, and others. As a result, this contributes to low hydropower generation and exacerbates power shortages, eventually reducing adaptive capacity. Similarly, Zone II receives rainfall between 800 to 1000mm annually, and houses major hydropower plants such as the Kafue Gorge Hydropower plants and Itezhi-Tezhi in the Kafue sub-catchment of the Zambezi River Basin. Zone III in the Luapula and Chambeshi sub-catchments of the CRB receives over 1000mm annually, having plenty of water to generate hydropower. Unfortunately, no major hydropower technologies are installed there. The study results suggest that major plants should be located in high rainfall zones where there is plenty of water to generate power and increase adaptive capacity. Therefore, locating new hydropower generation plants in the LRB can complement power generation during drought. Owing to this, the Manager at ZESCO revealed in a personal interview that ZESCO is trying to develop new hydropower plants in the Luapula River and Chambeshi River areas, as they are believed to be less affected by drought.

> *Hence, one of the strategies we are looking at is the capacity in the Congo River Basin so that if there are drought consequences in the southern region, we can consider the generation capacity in the Congo River Basin. The Congo Basin harbours potential rivers like the Luapula and Chambeshi. We are looking at developing additional hydropower capacity by constructing both small and large hydropower stations in the north, so that they can help mitigate the negative consequences of drought in the Kafue River Basin. The small hydropower stations will be connected to the national grid so that if there is not enough generation in the south, we can depend on the generation from the north.* (Interview 3L, 16 March 2016).

A Senior Manager at ZESCO also revealed that ZESCO is exploring new sites in the LRB for the construction of new hydro power plants to generate more hydropower during drought. The sites in the KRB are becoming more prone to drought, so even when ZESCO adds capacity, the challenges of drought still persist because the locations of power plants remain unchanged.

> *If we add capacity at the same location, usually we still end up with the challenge of increasing the amount of power because we are still dealing with the same site and amount of water, so usually it causes a lot of challenges. However, if we maybe move to different locations on other rivers such as Luapula River Basin and the Chambishi River Basin in the north, then we will be able to add capacity to the total amount of power in the system and reduce drought impacts. I think the plan now is to build power plants at different locations so that we can add more generation capacity to the system by going to other rivers and building power plants.* (Interview 1L, 15 March 2016).

This means that the location of plants and technology will significantly vary, which will enhance the available options for drought response. Once variation of technology has been achieved through the use of different river basins, adaptive capacity can also be achieved by avoiding drought-prone locations in the ZRB. Moreover, the ZESCO Managing Director revealed that these developments have already started. ZESCO and SNALE – a power utility company in the Congo, are in the preparatory phase of constructing new power plants in the LRB:

> *Apart from KGLPP, we have a lot of sites. We have more than 1000 MW in the Luapula River Basin. The Luapula River is a shared water resource so ZESCO has to develop*

sites in conjunction with our neighbouring Democratic Republic of Congo and the utility called SNALE. We have already signed a Memorandum of Understanding and we established a special purpose vehicle that will be operationalised to ensure that we construct the sites in the Luapula River Basin. (Managing Director 1L, 2016).

Therefore, the location of hydropower power plants can help to create the requirements to achieve high adaptive capacity of hydropower organisations to cope with drought. When hydropower plants share a common location, drought effects are severe because the technologies suffer the consequences of drought at the same time and in the same way, resulting in low coping capability. Nevertheless, the concentration of new power plants in a different basin will achieve diversity of location, which enhance adaptive capacity.

4.5 WHY IT HAS TAKEN SO LONG FOR ZESCO TO CREATE ADAPTIVE CAPACITY TO COPE WITH DROUGHT?

The study results revealed that for a very long time, ZESCO has been comfortable with hydro-based power plants and technologies to preserve the image and identity of the organisation. That being the case, ZESCO's problem concerning lack of technology was overshadowed until recently when drought induced enormous challenges of water scarcity in the Kafue River Basin. A manager mentioned that the intention of ZESCO to diversify technology to other types, especially non-hydro technologies, was influenced to a large degree by the severe drought of 2015/2016 in the Kafue River Basin.

> *We have been a company that has not cared much about alternative energy sources. We have been very comfortable with hydropower. Hence, with the emergence of drought, as an impact of climate change, we realised that we needed to invest in alternative sources of energy, although finances are proving challenging.* (Interview 4S. ZESCO, 16 March 2016).

Financial resources had limited the development of technology (diversity and extensions) and in so doing, has constrained the adaptive capacity of ZESCO to cope with and adapt to drought. ZESCO as a single entity, could not acquire financial resources, especially in the form of loans, without the help of government. And even though it has many plans on the table to improve its technology, lack of financial resources continue to act as a barrier.

> *Talk about huge capital outings for some projects that have been on the shelf for some time. For example, the biggest project we are implementing is the Kafue Gorge Lower. We have a challenge with this huge investment because financiers do not want to finance a project that will have negative consequences on the environment. There has been low attention paid to investment in the new generation capacity. Climate change issues are a major component in this. ZESCO is a parastatal, wholly owned by the Zambian government. Mainly, the government gets the money and lends it to ZESCO. Despite the fact that government borrows the money, the payments are made by ZESCO. This is because most of the funding agencies like to have bilateral agreements with the government. It is more secure than just with the company. The funds are sourced by government.* (Interview 3B. ZESCO, 2016).

This shows that financial constraints have been a challenge for ZESCO because the expansion projects of hydropower stations need huge investment, yet investment funds are limited.

Adaptation measures need a financial injection to be effected. The study revealed that many plans have been formulated by ZESCO for the purpose of increasing adaptive capacity, but limitations of funding have always been a challenge. There is simply not enough money to implement adaptive capacity projects and government has been slow to invest in hydro power technologies and infrastructure development and expansion. More precisely, there have been many problems in accessing funds in form of loans for implementing adaptation projects.

4.6 CONCLUSION

In concluding this chapter, it is vital to note that ZESCO's technology is limited. There are three important mechanisms in creating technological prerequisites for adaptive capacity to cope with climate change, and particularly drought. These include diversification of technology, generation capacity and the location of technology. First and foremost, the intention was to demonstrate how diversification of technology can play an important role in creating the necessary conditions needed to create adaptive capacity to drought. It is clear that diversification of technology is vital for increasing the available mechanisms to strengthen adaptive capacity. Diversification can help increase the range of technologies to be used as alternatives during drought. Moreover, as has been mentioned, diversification of technologies implies using other non-hydro technologies which are not affected by drought. Secondly, based on the findings of this study, the results also demonstrated that diversification of technology creates prerequisites for increasing adaptive capacity to drought. It is clear that technology can be used to increase the conditions necessary for enhancing adaptive capacity. This can be achieved through the construction of new technologies and through expansion of the existing technologies. Lastly, the study results revealed that varying the location of the technology in various river basins helps create the prerequisites for the promotion of adaptive capacity to drought, as it creates the required conditions to cope with drought. In this way, it makes difficult for drought to affect them in the same way and at the same time, due to the dissimilar weather and climate conditions. Therefore, varying the location of technology can maintain normal conditions for power generation by avoiding drought conditions in the same river basin. A situation that can lead to enhancing adaptive capacity. These results are discussed in the following chapter.

Owing to the reality of climate change, hydropower organisations must endeavour to put in place the prerequisites or necessary conditions to cope with drought in the short term and enhance adaptive capacity in a long run. However, there is a need to identify the options available to create a conducive environment for adaptations to take place. Therefore, having recognised that drought as an effect of climate change is problematic, hydropower organisations need to obtain the prerequisites that can help characterise adaptive capacity to climate change associated drought.

5 CHAPTER FIVE - DISCUSSION

5.1 INTRODUCTION

In this chapter, the findings of the study are considered and discussed. The chapter comprises three parts. The first part discusses how diversification of technology plays a role in creating prerequisites for enhancing adaptive capacity to cope with drought and its implications. In the second part of the chapter, the role of technology enhancement in creating conditions for adaptive capacity to cope with drought is outlined. In the last part of the chapter, how the location of technology influences prerequisites for promoting adaptive capacity to cope with drought is discussed.

From 2014 to 2016, the El Niño effect was alluded to have caused low rainfall over the Kafue River Basin and much of Southern Africa. Studies have shown drought to be an effect of climate change (see for example the World Food Programme, 2015; Mpanga et al., 2015). Thus, in this study, key aspects of drought include water levels in the river (Poshtiri & Pal, 2015). In this regard, some studies have demonstrated that the Kafue River Basin was impacted by a particularly severe drought in 2015 and 2016 as a result of climate variability (see for example Yamba, et al. 2011; Kaunda, 2013; Muzeya, 2015; Mpanga et al., 2016; IPRI, 2016). In a personal interview, the Chief Hydrologist at ZESCO associated the 2014-2016 drought with climate change:

One of the important aims of this study was to assess how diversification of technology helps in creating prerequisites of adaptive capacity to drought. For the purpose of this study, and borrowing from other authors (Ostrom, 2005; Bell, 2011; Page, 2011), adaptive capacity implies a state of different types of technologies being diverse or varied. In general terms, diversity represents availability and co-existence of diverse types of system components, behaviours and functions from a system-thinking perspective (Anderies et al., 2004). It is aimed at increasing the mix of different types of technologies to use during drought episodes. Diversity can improve productivity, enhance robustness and sustain further diversity of complex systems (Page, 2011).

The study supports the idea that drought is strongly associated with climate change (Yamba, 2011). Although not of particular interest to this study, it is worth mentioning that Zambia has experienced droughts in previous decades, but impacts on water security and power generation were not significant considering the fact that the population was low, industries were few, and mines and agriculture were on a smaller scale (Muzeya, 2015). It is clear that drought has become frequent as a consequence of climate change, resulting in detrimental decrease in water resources in the Kafue River Basin consequently reducing power generation and causing power outages. In another personal interview, a senior manager at ZESCO also perceived drought to be likely caused by climate change. He also revealed that drought had occurred there in the previous years.

As mentioned in the results chapter, even in the past drought situations have occurred in the Kafue River basin. So, what this means is that drought is part of the cyclic nature of climate, it is just a variability in climate from here to there. Considering long-term dataset, it was noticed that there have been some climate variability of a cyclical trend. After ten years of good rains, then drought, which is following a certain shift of some sort. The rains used to start early but now, instead of rains starting in October they start late in December with drought spells in between. Eventually you get some significant rain about March, hence its shifting. You cannot run away from climate change issues. What normally happens in the Pacific Ocean is indicative of what will happen around Kafue River basin. We have discovered that when the sea surface temperature is a bit higher, we have less amounts of water, especially in the southern parts of Zambia, and distribution of rainfall is also not good.

Therefore, such perceptions suggest that climate change is highly associated with drought in the Kafue River Basin, which subsequently leads to power shortages. In addition, the gap between drought occurrences and power generation is very thin as a result of limited technology which has remained stagnant over time (World Bank, 2015; Siliya, 2016).

5.2 HOW DIVERSIFICATION OF TECHNOLOGY PLAYS A ROLE IN INFLUENCING PREREQUISITES OF ADAPTIVE CAPACITY

This study shows that one of the key challenges facing ZESCO is the lack of diversity in their hydropower technology. This finding is in line with several other studies (Yamba 2011; Muzeya, 2014; Mpanga, 2016), which have noted that currently, over 99% of electricity comes from hydropower-based technology, and that most projects being developed have hydro-based technologies. This makes ZESCO vulnerable to droughts. As noted earlier, drought significantly reduces the water levels required for normal power generation in the Kafue River Basin. The homogeneous nature of the current technology allows drought to drastically disturb power generation beyond its capacity to adapt. This has prompted ZESCO, in the hope of sustaining water security for the ecosystem and river health, to reduce generation capacity, resulting in substantial power shortages (IAPRI, 2015; ZDA, 2015). Furthermore, they have failed to diversify the technology, especially into non-hydro types such as wind power, thermal and solar power. In short, the technology is limited by not having alternative power generation options. So, when drought occurs and undermines water security, the problem of power generation become extreme. These factors interact to affect conditions for creating adaptive coping capacity. Diversification of technology is thus required to provide these conditions.

The study has shown that a lack of technological diversity constrains adaptive capacity by limiting the range of alternative technological options for power generation, undermining conditions to stimulate adaptive capacity. While ZESCO is confronted with limited technology, it has the opportunity to diversify into other renewable energy technologies such as wind, thermal and solar (Muzeya, 2015), to help create adaptive capacity to drought. A wide range of technologies means a diverse composition of technologies. This provides a variety of options to generate power during drought, compared to having hydropower only, where the options are not available to complement the shortfall. When drought episodes occur, other technologies can still generate power and facilitate conditions for creating adaptive capacity. Moreover, most of the diversified technologies such as wind, solar and thermal do not depend on water to generate power. This implies that these technologies are stable, efficient and appropriate for use during drought. As a result, power generation would likely be strengthened and adaptive capacity amplified.

As the ZESCO case study illustrates, efforts to prioritise the diversification of technology, particularly those that are non-hydro based, must be targeted. It is likely that the distribution of drought impacts from the Kafue River Basin will be variable through technological diversity. The study reveals that Z|ESCO's drought-associated burdens are due to the lack of diverse technologies, and that this disproportionately affects hydropower generation. Furthermore, attempts to mitigate such burdens prove difficult owing to ZESCO's organisational propensity for being comfortable with hydropower technology only, and thus not having to invest in alternative technologies. This suggests that their inability to invest in other types of technologies has caused a huge limitation on diversification (ZDA, 2014). Government and the private sector through IPP have an important role in assisting ZESCO to diversify their technology through investing in alternative technologies. The researcher strongly believes that with this help, ZESCO will be able to create the prerequisites required for supporting their adaptive capacity to cope with drought (IAPRI, 2015; Mpanga, 2016).

Solar technology is one of the important potential mechanisms available for diversifying technology. It uses energy from the sun, which is abundant in Zambia, to generate power (IAPRI 2015). Studies have shown that solar technology is an appropriate, suitable and efficient source of power to use during drought periods (Mpanga et al., 2016; IAPRI, 2016). Evidence from the study shows that solar technology has the potential to provide over a 1000 MW of power, enough to have addressed the shortfall experienced in the 2015/16 drought period. Solar technology adds diversity to technology and helps increase options for energy sources during drought episodes. It also provides access to a wide range of technologies (see for example, ZDA, 2014; Mpanga et al., 2016), and is likely to contribute to creating the capability for generating power despite drought conditions (IAPRI, 2015). Solar technology is likely to provide an opportunity for ZESCO to diversify from hydro-based technologies and to establish solar power plants in various places.

The study has shown that thermal power technology has the potential to diversify hydropower technology. It is readily available, appropriate, efficient and suitable to increase the composition of technology options for drought episodes. As technology depends on coal, which it is abundant in Zambia ((Muzeya, 2015). Generally, thermal power technology has the potential to generate 1000 MW of power. This is enough to have mitigated the power shortages experienced during the 2015/16 drought period in Zambia. The technology is efficient because it is not hydro-based and hence is not vulnerable to drought. Coal is readily available in Zambia, making thermal power favourable for the diversification process. The development of coal energy could lead to diversification of technology and is what needs to be built in order to improve adaptive capacity (Yamba, 2011), and is likely to provide conditions for increasing adaptive capacity. In addition, another study by Mpanga (2011) highlights that energy mix through use of renewable energy technologies (RET), creates conditions that ensure availability of adequate energy supply from various sources. Zambia's Energy Policy of 2008, recognised coal as a contributory source to energy mix. For example, Maamba Coal Power Plant is developing 300 MW capacity through coal. This will help reduce dependence on hydropower and diversify their energy technology (IAPRI, 2015). In fact, diversifying to RET is seen as a viable means of mitigating energy shortages in Southern Africa (Yamba, 2011).

The study findings have shown that another way in which ZESCO is trying to achieve diversification is through wind power technology. Wind technology uses wind as a resource for energy generation, and so the technology is not affected by drought. Wind resources are available in Zambia, although at present the technology is only used for mechanical purposes.

Wind technology is appropriate in Zambia and would prove lucrative for diversification. This implies that despite drought episodes hampering hydro power generation, wind technology could help to provide power. Through wind power technology, hydropower organisations could create opportunities to invest and contribute to the required diversity of technologies, thus providing favourable conditions for adaptive capacity to cope with drought. Wind technology has the potential to ensure divergence from the hydropower technology that is currently under threat by drought (IEA, 2008).

Diversification of technology is likely to enable ZESCO to build adaptive capacity to cope to drought by increasing a variety of technology options to use as alternatives when drought occurs. These comprise wind power technology, thermal power technology and solar power technology (Muzeya, 2015). In this regard, it is reasonable for this study to suggest variability in of types of technology, which can create conditions for enhancing adaptive capacity. However, it is worth mentioning that in creating the prerequisites for adaptive capacity, hydropower technology mostly requires non-hydro based technologies that are capable of generating power during periods of drought. As evidenced in this case study, the nature of hydropower organisation of being wholly dependent on hydro-based technology has been identified as arresting adaptive capacity due to absence of diversification. In the same vein, Yamba et al. (2011) notes that the potential for hydropower in Zambia has a tendency towards a decrease for generation during drought episodes. , while it is anticipated that extreme events of higher droughts will be frequent, diversification of technology must be comprehensively prioritised as it is likely to create adaptive capacity by making available, technological options for power generation. In addition, the study also supports the (IPCC, 2007) climate change synthesis report suggesting that socio-ecological systems (hydropower organisations) based around water will have to adapt over time (Godden et al., 2011), and where technology diversification takes a complementary responsibility to enhance adaptive capacity.

The evidence in this study predominantly suggests that for a hydropower organisation to acquire adaptive capacity to cope and adapt to the effects of climate change, it must commit energies and resources towards building the required conditions of adaptive capacity, including technological diversity (see for example, Smit & Pilifosova, 2003; Smit & Wandel, 2006; Engle, 2011). It is important to remember that diversification serves only as a starting point which must be prioritised to enhance adaptive capacity conditions. As drought continue to threaten hydropower generation by altering water levels, hampering water security and escalating power shortages, it is crucial that ZESCO accelerates efforts to diversify its technology.

5.3 HOW THE GENERATION CAPACITY CREATES CONDITIONS FOR INCREASING ADAPTIVE CAPACITY

Impacts of climate change are likely to continue threatening water security, increasing risks for hydropower generation (Engle & Lemos, 2010; Yamba, 2011). In this regard, the capacity of hydropower organizations to adapt to such threats is critical (Folk, 2006). While ZESCO is subjected to such threats, its ability to increase generation capacity remains inadequate hence. Therefore, this implies that increasing the amount of power generation (capacity) is crucial to act as a precondition for adaptive capacity. The study supports the idea that increasing technology is associated with higher adaptive capacity.

The capacity of technology to generate power is a fundamental component that can enhance adaptive capacity if it's adequate, or undermine it when limited. For example, the case study shows that ZESCO has not been able to respond effectively to drought, partially because of its failure to expand its technology, which has been limited for a long time. In line with other studies (ZIPAR, 2015; IAPRI, 2016), the study suggest ZESCO's existing technology is limited in that it has not been upgraded, indicating issues of funding. Limited technology constrains the ability to generate adequate hydropower, particularly during drought, hence power shortages occur.

However, the study has demonstrated that one way of enhancing the conditions to increase adaptive capacity to cope with drought impacts on hydropower is by modifying the technology to suit current climatic conditions, including high electricity demand. To modify and increase technology, ZESCO's efforts to construct new power plants and expand their existing ones must be emphasised. Construction of new power plants can cause significant changes to existing technologies by adding generation capacity. For example, the findings illustrated earlier that some of the new hydro-based large-scale technology schemes include the KGLHPP, Batoka HPP and many small/mini-hydro power plants, mainly in, Luapula and the north-western provinces (Mpanga, 2016). Coal, solar and wind technologies are appropriate for installation. These undertakings will increase generation capacity, and far exceed the deficit experienced in the 2015/16 drought in the KRB. When constructed, the new power plants are likely to expand both hydro and non-hydro as well as small and large sized technologies. As illustrated by the Word Bank (2015), while Zambia has the potential of about 6000 MW of hydro power generation (ZDA, 2014), about 2300 MW has been used. The remaining 4000 MW indicate the potential for constructing new technologies in order to increase generation capacity (Muzeya, 2015; Mpanga, 2016; IAPRI, 2016) and will enable the required conditions for adaptive capacity. As a result, when drought hits power generation, there will be adequate capacity to generate the required power to reduce shortages. However, gains in creating conditions for enhancing adaptive capacity are likely to be less pronounced, as evidenced by the need to vary the locations of technology in other areas other than Kafue River. The new technologies must not only be installed in the KRB but need to be varied to create diversity, variability and variation of technologies to cope with drought. Increasing capacity to generate power in the same area is less effective and might see the drought impacts continuing.

Another approach to increase the generation capacity is by expanding the existing technologies by way of rehabilitation and upgrading. The study has revealed that ZESCO's power plant technology has remained constant over time, rendering it limited in scope. The current power plants are alleged to be limited because of the technology has not been adjusted to configure with present conditions of severe drought and increased demand due to the growing population, expanded agriculture, mines and industry (Wamulume et al. 2011). Both small and large scale power plants have to be enlarged, rehabilitated and uprated to increase power generation capacity. As illustrated earlier, the case study provides evidence of rehabilitation and upgrading of existing technology such as ITTHPP, which was uprated from 60 MW to about 120 MW capacity. The Maamba Coal power plant with 300 MW capacity is underway (Muzeya, 2015), as are others, suggesting additional technological capacity. This study has without doubt confirmed that new technology schemes of that magnitude reinforce the ability to generate power, resulting in improved conditions for adaptability and the mitigation of power shortages. Yamba (2011) added that these interventions are likely to result in conditions that might increase adaptation to climate change and drought.

The implication of this study follow the notion that adaptation to drought requires developing technologies to their full potential (Muzeya, 2015). Given that technology is being improved at ZESCO, power generation might be restored to normal and the company should be able to cope with drought and adapt to climate change. In the context of this case study, such actions will not only end power shortages and energy crises but also help to harness water security in the KRB. The harness of water security will come as a result of ZESCO being cautious with the use of water during power generation in terms of how much water can be released during power generation at a critical point of drought episode. For example during drought, the generation of hydropower is reduced in order to avoid massive depletion of water as a way of rationing the scarce resource thereby enhancing water security in the river basin. The findings are generally consistent with the IPCC prescriptions to enhance adaptation to climate change. Thus, the study suggests that increasing hydro and non-hydro power technology can be regarded as a prerequisite for creating adaptive capacity of hydropower organisations to respond to drought. It must be taken into account that the gap between power generation and power demand is accelerating, given the high frequency of drought and is inhibiting the conditions for adaptation to take place. ZESCO's generation of adequate electricity during drought is thus being hampered and thus the modification of their technology will prove rewarding by creating the needed adaptive capacity to cope with drought.

IAPRI (2016) suggests that to increase energy security, there is need to increase the capacity of hydropower, along with solar, thermal, and geothermal potential, and that to this end, private sector engagement is important. To mitigate power shortages, government and the private sector have indeed invested in the energy sector in order to increase power generation capacity. For example, the 300 MW thermal power plant at Maamba Collieries Limited will soon add to the current capacity. In addition, other efforts include rehabilitation of existing power plants, the construction of 600 MW solar power plants, and thermal and hydroelectric power plants. It is expected that all power projects will contribute to a total capacity of about 4,500 MW by 2025 (Kambwili, 2015; IAPRI, 2016). While approaches to increasing technology capacity have the potential to create conditions of adaptive capacity in the long run, in practice, ZESCO has done little to deal with project implementations in the short term, as confirmed by the respondents were quick to point out the role played by limited funds. Nonetheless, the development of The Power System Development Master Plan of 2008 boosted confidence by aiming at increase power generation capacity to 4500 MW by the year 2030 (Mpanga 2016). Therefore, in the case of this study, this implies that ZESCO has the potential to create adaptive capacity through increasing their technology.

While the study findings support the idea that technology plays an important role in creating conditions associated with higher adaptive capacity of hydropower organisations, more case studies at river basin scale are needed to strengthen the findings. The findings of this study are also in line with other studies (Muzeya, 2015; WFP, 2015; Mpanga, 2016; IAPRI, 2016), which show that developing technologies for renewable energy and improving performance are a vital response to drought. IAPRI (2015) reports that the current drought and power shortages underscore the importance of technology development as a requisite input in efficiency energy generation for economic development.

The Kafue River Basin is sensitive to high rainfall variability patterns. Hydropower technology is principally located in the Kafue River Basin, where water is already a scarce and contested resource, and the Basin is perhaps more affected by climate change than the Congo River Basin. However, the capacity of ZESCO to cope and adapt depends largely on the diversity of location and technology, which can indeed increase the generation of hydropower during drought episodes.

5.4 HOW THE LOCATION OF TECHNOLOGY INFLUENCES PREREQUISITES FOR ENHANCING ADAPTIVE CAPACITY

Adaptive capacity to climate change can also be understood from the location of technology point of view, in terms of varying the composition of various power plants across different river basins and climatic zones. The study notes that ZESCO's major technologies share a common basin (Zambezi River Basin and its sub-catchment, the Kafue River Basin (Jain, 2007; Thurlow et al., 2012; Phiri et al., 2013; Funder et al., 2013). The challenge is that when drought occurs and reduces the water levels and run-off in the basin, it exerts a considerable reduction on power generation because all the technologies are in the same locality and suffer the consequences in the same way and at the same time. This makes it difficult for a hydropower organisation to react to drought where nearly 99% of its dependence comprises hydro-based technology (Mpanga et al., 2016). However, it is evident that varying the location of technologies can be helpful in creating the conditions necessary to enhance adaptive capacity to drought, which can be achieved by concentrating on building new technologies in the Congo River Basin in the upper region of Zambia.

The importance of varying locations is clear: that it can create adaptive capacity by avoiding localities that are prone to drought. Varying the location of plants involves construction of new plants in the CRB, which houses the sub catchments like the Luangwa and Chambeshi, which purportedly have plenty of water suitable for power generation (Yamba et al, 2011). This will enable ZESCO to have a diverse composition of power plants located in various areas with distinct climatic conditions. For example, as has been shown previously, Zambia has three climatic zones: Zones I. II and III. Zones II and III consist of major hydropower plants, including the Kafue Gorge Upper Hydropower plant, the Itezhi-Tezhi, Victoria Falls, Batoka and Kafue Gorge Lower plants, as shown in several studies such as those of Wamulume et al., (2011); Yamba et al., (2011); Thurlow et al., (2012) and the World Bank, (2014). The implication is that since power plants share common location, the consequences of drought follow the same fashion, resulting in huge a decrease of power generation capacity. The decrease is partially due to having the technologies in the same locality. , varying the locations of hydropower plants have complex structure and composition of power plants in different river basins with distinct climatic conditions. In so doing, ZESCO is likely to avoid drought.

Water security is the key to the suitability of the Congo River Basin in considering varying the location of hydropower plants. The Congo River Basin is perceived to be much less prone to drought than the Kafue River Basin, and hence a suitable locations. Although it was not in the interests of this study to assess competition of water resources between the two basins, it is vital to mention that the Luapula and Chambeshi rivers are perceived to have less competition for water use than the Kafue River Basin, making them adequate for hydropower generation. Moreover, the Congo River Basin connects from the equatorial rain forest where perennial rains provide abundant water to the Luapula, Chambeshi and other rivers, which reduce vulnerability to drought. This means that plants could be installed in this zone to bring about variability of location and to enable ZESCO to overcome the current struggle of enhancing adaptive capacity to cope with drought. Yamba et al., (2011) mentioned a similar plenitude of water in northern of Zambia in the Congo River basin.

For example, when drought impacts on the power plants located in the KRB, the ones in the Congo Rivers Basin can still generate power and complement shortages. This can help ZESCO reduce vulnerability to drought. This is similar to what IAPRI (2015) stated in their electricity sub-sector report: that there is potential for the rivers in the northern part of Zambia to create hydropower plants such as the Luapula River Basin Hydro Power Plant, which will generate about 1200MW by 2019, and many other small hydro power plants which will help to spread the hydrological risks. This will assist hydropower organisations to develop the conditions required for adaptive capacity, and will be vital in combating the energy crisis in Zambia.

Similar to Yamba et. al (2011), the study further indicates that the manner in which power plants are located in the KRB contributes to ZESCO's vulnerability as it limits the hydropower technology diversity. Therefore, varying the locations of technology can help promote complexity and reduce vulnerability to drought. There is considerable scope to vary the location of technology as shown in chapter four. This situation gives hope of a solution to boost the adaptations to drought and combat the current power shortages taking place in Zambia (Mpanga, 2016).

Drawing from Smit and Wandel (2006), a paper on concepts of adaptation, adaptive capacity and vulnerabilities indicated that adaptation prerequisites are vital in exploring the degree to which they can reduce negative impacts of climate change.

The study has addressed adaptive capacity in line with the requirements of the articles of IPCC and UNFCCC which state that measures must be formulated to implement and facilitate adequate adaptations to climate change impacts, while efforts must be directed to those locations with the least adaptive capacity. The study is in line with that of Smit et al., (2001) who asserted that in general, action to enhance adaptive capacity to cope with drought is consistent with the action to promote development. In addition, Smit and Wandel (2006), suggested that while adaptive capacity may reflect stability, robustness, resilience, flexibility and other system characteristics, enhancing its prerequisites should be a priority.

5.5 HOW ORGANISATIONAL IDENTITY AND FINANCIAL RESOURCES CONSTRAIN ZESCO's ADAPTIVE CAPACITY

As shown in Chapter Six, ZESCO has been crippled by drought, mainly due to lack of financial resources and political barriers. The study revealed that time and again, ZESCO has tried to diversify and increase its technology and vary the location of its plants in order to create conditions for adaptive capacity to cope with drought.

This research has shown that ZESCO's perceived weakness in adaptive capacity has mainly been caused by lack of access to financial resources. The company's failure to develop technology and infrastructure is, in part, a consequence of how the utility defined its business and preserved its sense of security. It was more concerned with its organisational identity and image without giving due cognisance to the reality of its complete dependence on hydro. Financial resources meant for technology development have always been a challenge and the government has been reluctant to facilitate financial accessibility, especially in the form of international loans.

To some extent, the organisational image and identity of ZESCO has been portrayed to the public as "all is well". This pretence influenced the company's perceptions on the need for investment. ZESCO now seems to be redefining its image, and with that change has come a greater willingness to realise that investment in its infrastructure is vital. This finding is in line with other studies which support the assertion that the organisation is portraying itself differently. For example, identity, culture, image and vision show the character of an organisation and are considered by the public as most important factors (see for example, Whetten & Godfrey, 1998; Gioia et al., 2000). Image, in the sense of holistic impression (of ZESCO) always exists in attitude, perception, opinion, and views (Ashforth & Mael, 1989; Alvesson, 1990). When ZESCO came under the spotlight for not securing power for the nation and its reputation came under pressure, self-interest (and of course national interest), mobilised its transformation to a new business identity and model. Therefore, organisational identity and image played a major role in the manner that adaptive capacity can be constrained or enhanced by the way in which an entity chooses to define itself. Being a hydro-based entity has shown time and again that it does not help in any way to respond to the effects of climate change associated drought by constraining the capacity to adapt. The situations enumerated above have caused ZESCO to take a long time to create adaptive capacity. Dutton and Dukerich (1991) observed that organisations can be proactive in pursuing change, even in the absence of environmental stress. Whetten and Godfrey (1998), posited that to induce change an organisation must be destabilized and take a different approach. In this regard, ZESCO's identity and image had to change to avoid the public perception that the entity is well placed with hydro only.

The study has shown that organisations want to retain their identity and image, especially when threatened with change. This is in line with other authors who claim that some organisations typically change in order to remain what they always have been (Alvesson, 1990; Dutton & Dukerich, 1991; Gioia et al., 2000).

5.6 CONCLUSION

This chapter has discussed the findings and implications of the study with regard to the literature. The study noted that the adaptive capacity of ZESCO is well understood from a technology point of view at the river basin scale. Climate change and reduced rainfall associated droughts are becoming frequent, posing serious threats to water security and having devastating consequences for hydropower generation in the Kafue River Basin (IAPRI, 2015, IAPRI, 2016). It is also evident that technology is generally limited to cope with and mitigate against such threats. However, the study has illustrated the potential of hydropower organisations to create the necessary conditions for increasing adaptive capacity to cope by modifying technologies, which must be improved to suit the current climate change conditions.

The chapter discussed findings regarding the dimensions of diversification of technology. It has been suggested that diversification of technology is most likely to create the conditions needed to increase adaptive capacity. Diversification builds a range of different types of technology, especially providing access to those that are non- hydro, which can limit the negative consequences of drought. Diversity of technology suggests having other, dissimilar types of power plants that use wind, thermal and solar power technologies to generate power during drought episodes. This is likely to restrict drought because of variability. Moreover, diversified technologies will generate power and complement the sagging hydro-based technology which is vulnerable to drought. There is little doubt that diversifying technology is likely to create conditions that can amplify adaptive capacity to drought.

In the same purview, the generation capacity if well nested, can play a vital role in creating conditions for stirring adaptive capacity to cope with drought. While the generation capacity has proved low considering the power shortages which have continued, increasing the capacity is essential in creating room for activating adaptations to an extent where the capacity to generate power becomes remarkably excessive. It was eminent in this study that the generation capacity can be enhanced in two way: by constructing new technologies in various river basins. This will substantively increase the generation capacity Therefore, this enables one to believe that increasing the generation capacity is likely to help remedy ZESCO's power shortages and energy crisis in Zambia.

The location of technology can amplify or undermine power generation depending on where the technologies are placed. The study shows for example that when technologies share the same river basin, drought takes advantage and reduces the power generation on a large scale as compared to when the locations are varied. Varying locations of technology can make ZESCO avoid drought by way of creating complex structure and composition of the locations of technology in various regions. It was learnt that identity and image are major concern as they portray different ways of the organisation under threat to incise the public while things are not okay. The problem lies in the rigid of the organisation to change while maintaining its identity.

6 CHAPTER SIX - CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter presents the conclusions and recommendations of the study. The chapter draws conclusions from the results obtained, as presented in Chapter Four, and highlights the implications of the study. First, conclusions from the diversification dimension of technology are drawn. Thereafter, conclusions are provided on the dimensions of technology. The first section of the chapter ends with conclusions on the location dimension of technology. Finally, in the second part of this chapter, policy recommendations are made, followed by recommendations for ZESCO and for further studies in order to improve the understanding of adaptive capacity of hydropower organisation to cope with drought.

6.2 REVISITNG THE TECHNOLOGICAL DIMENSIONS OF ADAPTIVE CAPACITY

The purpose of this study was to assess the adaptive capacity of hydropower organisations to cope with drought-associated climate change. The study has illustrated how climate change places enormous challenges on water resources and hydropower organisations. It has demonstrated the vital association between drought in the Kafue River Basin and the escalating power shortages perceived to be caused by climate change. These perceptions attribute the low generation of hydropower to drought, leading to power shortages. Moreover, the lack of technology is perceived to constrain the adaptive capacity to cope with drought. In this regard, while focusing on technology, the study highlighted the importance of determining the prerequisites for adaptive capacity in the context of hydropower organisations.

The study demonstrated how the three dimensions of technology: diversification, capacity, and location play a critical role in creating the conditions necessary to enhance adaptive capacity to cope with prevalent drought. The study was based on the premise that drought-associated climate change has continued to impact negatively on water security, thereby reducing water levels in the basin and decreasing power generation as demonstrated by such studies as (Yamba et al., 2011; Hamududu & Killingtveit, 2016; IAPRI, 2016). In addition, technology is becoming limited in its ability to create conditions necessary to cope with prevailing drought. In combination, these factors characterise the failure of hydropower organisations to enhance their adaptive capacity to deal with climate change. The study has further revealed that climate change impacts are projected to be extreme and are likely to cause more droughts. Consequently, the resulting drought is anticipated to reduce water levels to a large extent in Southern Africa, resulting in decreased generation of hydropower as also noticed by (Yamba et al., 2011). As previously stated, the limited technology in terms of, diversity and location is of concern. To create capacity to adapt to such risks, it is essential for hydropower organisations to commit energy and resources towards the development of technology.

This being the case, the study has revealed that one way of achieving increased adaptation capacity is by creating the necessary conditions or prerequisites of adaptive capacity through the diversification of technology. ZESCO should diversify its means of generating power, which will most likely increase its variety of options for generating power. Diversifying technology is a mechanism which can enable the establishment of wide-ranging technology including solar power, wind power, and thermal power technologies. During drought episodes, these diversified technologies will help mitigate power deficits such as those of 2015/16 in Zambia (Kambwili, 2015; Siliya, 2016; Personal interview, 2016). This, too, will allow the already scarce water in the basin to be protected from over use and heighten water security, given that the diversified technologies are non-hydro and do not suffer from drought impacts. In view of the foregoing analysis, it is clear that diversification will be rewarding in creating conditions for adaptation, since climate change associated droughts are persistently disturbing power generation. Therefore, having different types of technologies will reflect the diversity of power plants in their different responses to drought. Diversifying the mix of power generation technologies is sustainable, reliable and affordable. It is therefore tempting to be confident that diversifying into other renewable technologies will most likely solve the energy crisis in Zambia and promote water and energy security through creating adaptable environment for hydropower generation. This is also in line with (see for example Mpanga, et al., 2016).

The study also revealed that technological capacity affords great potential for hydropower organisations to create prerequisites for enhancing adaptive capacity to cope with drought. Based on the study, options for increasing technology can be achieved in two ways: by constructing new power plants, and by expanding the existing plants. Once this is done, power generation is most likely to be boosted during drought. The construction of new power plants will increase the capacity to generate more power so that even when drought occurs, power generation will still be maintained without creating shortages. New technologies will add the needed power generation capacity to mitigate power shortfall resulting from drought.

To increase technology capacity for increased power generation against the prevalent droughts, it is important that rehabilitation programmes, upgrades and uprating are given priority as adaptations strategies for drought. While technological capacity is generally perceived limited in terms of generation capacity, ZESCO needs to exploit the existing hydropower potential, especially in the areas least impacted by climate change in line with (IAPRI, 2016). Indeed, technology requires expansion for enhanced power generation. Expansion involves transforming small hydropower plants into larger scale plants and rehabilitating and uprating the large-scale plants to maximum capacity level in order to gain maximum power generation. In this way, the capacity of power generation, which is currently limited, will be expanded. The expansion and rehabilitation of the technologies will create power generation capacity that will be sufficient to overcome drought and enable ZESCO become adaptable to drought related climate change.

It is clear that if varying the location of technologies can be prioritised, it can bring about new power plants in different locations and reduce the consequences of drought thereby increasing diversity. As a result, it is likely to create the necessary environment for enhancing adaptive capacity to cope with drought. ZESCO needs to develop new technologies in the Congo River Basin to take advantage of the abundant waters rather than concentrating efforts in the Kafue River Basin with substantial droughts. Once technology is located on various rivers, ZESCO can be more proactive to avoid drought impacts and provide capacity to cope and adapt to drought. In addition, it is tempting to believe that varying the location of technologies can perform reasonably well as a prerequisite for enhancing adaptive can be used to deal with climate change impacts alongside well documented mitigation measures by the IPCC.

On the whole, however, for such efforts to work there is need for total commitment towards prioritising the development of technology. The continued decrease of power generation and power shortages pertaining to drought is the demonstration of limited technology with regard to power generation capacity of the technology, diversification and location. The failure by hydropower organisation to create prerequisites for adaptive capacity to cope is perceived to characterize low adaptive capacity to cope with drought. Adaptive capacity requires putting in place prerequisite that will amplify technologies to cope with climate change. Therefore, this study suggests the need for hydropower organisations to consider creating conditions that necessitate adaptive capacity. Doing so could reduce the impacts of drought on hydropower technology that have, for a long time, been struggling to generate sufficient power to curtail power shortages. Furthermore, the study has demonstrated that ZESCO is likely to enhance adaptive capacity and cope with drought in the Kafue River Basin. Thus, power generation is likely to increase and reduce power shortages. If ZESCO creates capacity for adaptation, drought will no longer have a lethal impact on hydropower generation.

6.3 RECOMMENDATIONS

The proposed recommendations are based on the findings of this study for creating the required prerequisites for the adaptive capacity of hydropower organisations in order to cope with drought. Recommendations are in three categories: policy recommendations; recommendations for ZESCO; and recommendations for further research.

6.3.1 POLICY RECOMMENDATIONS

Recommendations for policy are important in creating awareness and developing a road map for policy formulation. Sound policy formulation has been amongst the greatest successes of research implementation. With reference to the results presented in Chapter Four and the discussion in Chapter Five, the following recommendations are suggested with a view to improving the adaptive capacity of hydropower organisations in the Kafue River Basin, and in many other basins, at policy level.

- The literature suggests that climate change will continue to have detrimental impacts on water security in river basins (IPCC, 2007). It must therefore be deduced that hydropower generation in river basins will be affected by such external shocks. The study therefore recommends that water user groups i.e. hydropower organisations, should start creating adaptive capacity to cope with drought. Governments should create a deliberate policy to provide funding for the development of climate change projects with regard to hydropower organisations. Moreover, given that the private sector has a vital role to play in investing in the energy sector, it is recommended that government should increase access to financial resources in order to attract private sector financing. This will help to create an economic environment conducive to the promotion of investment and the financing of projects.
- Based on the results of the study, it is clear that hydropower organisations are highly vulnerable to climate change because they completely depend on water. As drought become persistent, their generation capacity will continue to reduce unless measures or conditions to increase adaptive capacity are put in place. For example, as a result of climate change, the deficit of ZESCO’s hydropower generation was about 1000 MW between 2015 and 2016, due to drought and limited technology to cope (Phiri et al., 2013). It is strongly recommended that government should strengthen its commitment towards the implementation of energy and water policies, which seems to be sagging. Moreover, government should add some aspects of climate change adaptation to its programme, in support of water security for hydropower water users in the Kafue River

Basin. Further, energy diversification policy requires a more aggressive approach to investing in Renewable Energy (RE) technologies. Therefore, if government selects ZESCO to diversify its technology, it must put in place the supplementary policies and institutional frameworks necessary for the development of RET (Yamba, 2011). It is suggested that there is a need to develop policies that are climate-proof in order to reverse the negative effects of drought on power generation.

6.3.2 RECOMMENDATIONS FOR ZESCO

- The study has shown that the adaptive capacity of ZESCO is constrained. This situation is likely to persist if climate change continues to impact on water security as projected. This study has demonstrated the potential to minimise the problem by developing technology that can cope with drought. It is highly recommended that ZESCO, acting together with all other stakeholders, should: (i) prioritise diversification of its technologies. ZESCO should identify and prioritise adaptive capacity and promote diversification of technology which can offer high adaptive capacity to cope with climate change, avoid drought, spread the risks of drought and increase hydropower generation. (ii) Prioritise expansion of technologies. In view of the fact that population and competition for water resources have increased over the past decades, it is recommended that ZESCO expand its technologies in order to increase its generation capacity and respond to current and future anticipated conditions, especially those imposed by climate change. It is advisable that the expansion should be on both large and small as well as hydro- and non-hydropower plants. (iii) Prioritise varying the locations of technology. It is suggested that ZESCO targets the northern region (Congo River Basin) which is purportedly less prone to drought and richer in water resources than the southern region of the country (Yamba et al., 2011), in order to vary its locations and enhance adaptive capacity to drought through the construction of new plants.
- In line with IAPRI (2016), it is recommended that ZESCO address operative inefficiencies in order to avoid power losses and facilitate finance for investing in adaptation projects such as technology development. Moreover, since climate change is projected to continue impacting on the security of water resources in the river basin, ZESCO should build and strengthen capacity in its own scientific research division with regard to energy and climate change.

6.3.3 RECOMMENDATIONS FOR FURTHER RESEARCH

- The consideration of one particular component of adaptive capacity without unravelling others could have belittle the understating of adaptive capacity. for this reason, I advise that since the conclusions of this study are based only on one component of adaptive capacity, that being technology, the remaining components should also be assessed using a similar approach, as they function in a complementary fashion with technology and not in isolation. They include: infrastructure, economic resources, institutions, equity, information and skills (IPCC, 2001; Eakin & Lemos 2006; Engle & Lemos, 2010). It is therefore recommended that a study be done to assess the adaptive capacity of hydropower organisations to the impacts of climate change, focusing on the determinants of adaptive capacity other than technology, in order to draw conclusions from all the above determinants.
- As there are various levels for conducting research, this study was conducted on a river basin scale (the Kafue River Basin). However, the study reckoned that little research on adaptive capacity has been conducted at river basin scale. So, it is imperative, to assess adaptive capacity of hydropower organisations in responding to drought at river basin scale in Zambia, and develop indicators for technology adaptation and water security. On the other hand, since climate change continues to weaken water security in the Kafue River Basin and many others, it is recommended that similar research be done on a much smaller scale such as at community level, individual level, water user group level and many more, to assess adaptive capacity.

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APPENDICES

APPENDIX A: HUMAN ETHICS CERTIFICATE OF APPROVAL

MONASH University
Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

This is to certify that the project below was considered by the Monash University Human Research Ethics Committee. The Committee was satisfied that the proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and has granted approval.

Project Number:	**CF16/282 - 2016000128**	
Project Title:	**Exploring the Adaptive Capacity of Hydro-Power Water User Organizations to the Effects of Climate Change: A Case Study of Kafue River Basin, Zambia**	
Chief Investigator:	**Assoc Prof Bimo Nkhata**	
Approved:	**From: 3 February 2016**	**To: 3 February 2021**

Terms of approval - ***Failure to comply with the terms below is in breach of your approval and the Australian Code for the Responsible Conduct of Research.***

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, before any data collection can occur at the specified organisation.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by MUHREC.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must include your project number.
6. **Amendments to the approved project (including changes in personnel):** Require the submission of a Request for Amendment form to MUHREC and must not begin without written approval from MUHREC. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Nip Thomson
Chair, MUHREC

cc: **Mr Musyani Siame**

Monash University, Room 111, Chancellery Building E
24 Sports Walk, Clayton Campus, Wellington Rd
Clayton VIC 3800, Australia
Telephone: +61 3 9905 5490 Facsimile: +61 3 9905 3831
Email: muhrec@monash.edu http://intranet.monash.edu.au/researchadmin/human/index.php
ABN 12 377 614 012 CRICOS Provider #00008C

APPENDIX B: ZESCO GATE LETTER

ZESCO

Our Ref: A200/HRD/501/2016

10 March 2016

Mr Musyani Siame
C/O Monash University
144 Peter Road
Ruimsig
SOUTH AFRICA

Dear Mr Siame

REQUEST TO CONDUCT RESEARCH – MR MUSYANI SIAME

Reference is made to your letter to us, wherein you requested ZESCO Management to grant you permission to carry out a research entitled **"Exploring the Adaptive Capacity of Hydro Power Water User Organisations to the Effect of Climate Change: A Case Study of Kafue River Basin, Zambia"**.

This serves to inform you that permission has been granted to you to undertake the above mentioned research under the following terms and conditions:

1. That all information regarding the research should be handled with all the confidentiality it deserves and shall be used for academic purposes only.
2. The final report should be availed to the office of the undersigned before submission to your school for a go ahead in writing.
3. A copy of the final report shall be retained by ZESCO Limited for future reference.
4. You are only permitted to carry out your research in the following department:

ITEM NO.	DIRECTORATE	DEPARTMENTS
1	Generation	Generation Support Services
2	Strategy and Corporate Services	Environment and Social Affairs Unit

Please fill in the attached form to indicate whether or not you are agreeable to these Terms and Conditions and return a copy to the office of the undersigned.

All correspondence to be addressed to the Managing Director
ZESCO Limited, Stand No. 6949 Great East Road, P.O. Box 33304, Lusaka-Zambia
Tel: +260-211-361111, Fax: +260-211-222753, E-mail: zesco@zesco.co.zm
www.zesco.co.zm

10 March 2016

Mr Musyani Siame
C/O Monash University
144 Peter Road
Ruimsig
SOUTH AFRICA

REQUEST TO CONDUCT RESEARCH – MR MUSYANI SIAME

Yours Sincerely
ZESCO LIMITED

[redacted]

RHODA K MWALE (MRS)
SENIOR MANAGER – HUMAN RESOURCE DEVELOPMENT

CC: Director – Human Resources and Administration
Senior Manager – Generation Support Services
Chief Engineer – Hydrology
Chief Environment and Social Analyst – Environment and Social Affairs Unit
Human Resources Manager – Generation
Human Resources Manager – Strategy and Corporate Services
Principal Human Resources Officer – Human Resource Development
Training File

RKM/fs

10 March 2016

Mr Musyani Siame
C/O Monash University
144 Peter Road
Ruimsig
SOUTH AFRICA

REQUEST TO CONDUCT RESEARCH – MR MUSYANI SIAME

I [redacted] .... *agree/~~do not agree,~~ to the above Terms and Conditions. Phone No: [redacted] ....

Signature: ...... [redacted] .... Date: 11/03/2016 ....

***Delete that which is not applicable.**

Witness: [redacted] .... Phone No: [redacted]

Date: 11/03/2016 ....

APPENDIX C: CONSENT FORM

MONASH University

CONSENT FORM

(Managers at ZESCO)

Project Title: **Exploring the Adaptive Capacity of Hydropower Water User Organisations to the Effects of Climate Change in Zambia: A Case Study of the Kafue River Basin**

Chief Investigator: **Associate Professor Bimo Nkhata**

I have been asked to take part in the Monash University research project specified above. I have read and understood the Explanatory Statement and I hereby consent to participate in this project.

I consent to the following:	**Yes**	**No**
Audio recording	☐	☐
Interview	☐	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

- **Audio and/or video recording during the interview / focus group**
- **Taking part in a focus group of up to (insert the general number) people**

- **The data that I provide during this research may be used by ____ in future research projects**.
- **The blood/tissue samples that I provide during this research may be used by ____ in future research projects**.

Name of Participant ……………………………………………..…………

Participant Signature ………………….. Date ………………………………

APPENDIX D: EXPLANATORY STATEMENT

MONASH University

EXPLANATORY STATEMENT

Managers at Zambia Electricity Supply Company (ZESCO) HQ and Kafue Gorge hydropower Station

Project Title:

Exploring the technological Conditions for the Adaptive Capacity of Hydropower organisations to The Effects of Climate Change: A Case Study of ZESCO in the Kafue River Basin, Zambia

Project Number:

Chief Investigator's Name

Associate Professor Bimo Nkhata

Department of social science
Phone:+2711954453
email: bimo.nkhata@monash.edu

Student's Name: *Musyani Siame*
[redacted]

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses above.

What does the research involve?

The purpose of this study is to explore the adaptive capacity of hydropower water user organisations to the effects of climate change so as to establish the cause, with particular reference to the role of monitoring systems, and to evaluate the impacts of adaptive capacity on water security.

Explanation of what the participants will be asked to do, and how much time it will take.

The participants will be asked to answer the questions during the interviews. Consent will be issued by the participants. After that, the researcher and each participant will make an appointment for tan in-depth interview meeting, with time and venue clearly stated, depending on the participant's preference. Interviews will be held in private offices, with only the researcher and participant present. Audio recordings of all interviews will be made. Before the recording, respondents will be made aware that they will be recorded, and their consent will be requested. The researcher will carry out the interview with semi-structured questions. The researcher will have guiding themes, but will allow the participant to expand and explain their views without limitation. Participants will be asked to offer explanations, descriptions and experiences in relation to climate change and adaptive capacity in a detailed way. The interview will be take a maximum of 30 minutes and will take place between 8am and 4pm.

Why were you chosen for this research?

You are employees of ZESCO's Kafue Gorge Upper Hydropower station, which is under study. Participants have vast knowledge and experience in their respective fields. They are the managers of different departments and hence have most of the information required for this study. The participants are directly in contact with water resource challenges at river basin level. Others are in planning for the organisation and are hence required to contribute to the data collection. Finally, the all the participants are members of the hydropower water user, which is under study.

Source of funding

The research will be sponsored by the International Water Security Network. The International Water Security Network is funded by Lloyd's Register Foundation, a charitable foundation that helps to protect life and property by supporting engineering-related education, public engagement and the application of research. For more information, go to: www.lrfoundation.org.uk

Consenting to participate in the project and withdrawing from the research

Before getting started, the researcher and the main supervisor will travel to the study site to conduct a scoping study in which the supervisor will introduce the researcher and the research project to the participants. The researcher will provide consent forms and request permission from the participants at this stage. The participants will sign the forms and the researcher will collect them. The participants will inform the researcher about the progress of the consent via cell phone or email. Secondly, there will be a discussion with each of the participants pertaining to the study and what it intends to do. Thereafter, the researcher will make appointments and set dates for interviews with each of the participants.

The participants will be granted the right to withdraw from further participation at any stage. It is hoped that they will recommend an alternative participant, such as a deputy manager, to avoid compromising the research process. In this regard, the participants may not be able to withdraw from the research process during the actual interview process; withdrawal may only be made before the interview, to create ample time to arrange for alternative participants.

Confidentiality

Only the student researcher and the chief supervisor will have access to the data, in line with the University's Records and Archives guidelines. The information will be stored on the personal computer of the student researcher with a security password, in order to lessen the risk of loss, theft or inappropriate use of the data. On completion of the study, the data will be the property of Monash University and the Monash policy concerning data storage will be followed. The researcher will make sure that the documents are safely locked away. Apart from the supervisor, no any other parson will be allowed access to the data, which will be treated as confidential.

(ii) How you will manage the information when published and (iii) how you will publish or report your data e.g. at a conference, as a thesis etc. If applicable, mention use of pseudonyms/codes etc.

I will follow the Monash policy concerning the use of data. When it will be time to publish the results, I will have to do so under Monash requirements. The publication of the research findings in form of the article will be done under Monash University as the custodian. The same applies to the thesis. Monash University will be the full owners of the thesis. There will be a publication conference at Monash University. The thesis results will involve the use of codes and themes to represent the participants, to maintain confidentiality and protect the participants from any problems that might arise.

Storage of data

Data will be in form of interview transcripts written in English, and also in the form of voice recordings. Only the student researcher and chief supervisor will have access to the data in line with the University's Records and Archives guidelines. The data will be the property of Monash University and therefore, the Monash policy concerning data storage will be followed. The data will be surrendered to Monash University and all the necessary storage protocols will be followed. The Monash University rules render data expired after five years.

Results

The results will be made available by July/August 2016, at Monash South University. The participants will have access to them through email.

Complaints

Should there be any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer

Monash University Human Research Ethics Committee (MUHREC)

Room 111, Building 3 Research Office

Monash University VIC 3800

Tel: +61 3 9905 2052

Email: muhrec@monash.edu

Fax: +61 3 9905 3831

Chief Investigator's signature:

Chief investigator: Associate Prof. Bimo Nkhata

APPENDIX E: IN-DEPTH INTERVIEW GUIDING TOPICS

To collect data, the study employed the in-depth interview data collection in which it gave room to the interviewee to explain in depth about the phenomenon under a particular topic. The interviewer did not restrict the respond's freedom to express himself/herself as reaching detail was the need. Therefore, the in-depth interview was guided by topics as shown the table below.

MAIN TOPIC	PARTICULAR TOPIC
WEATHER AND CLIMATE	• Monitoring systems • Weather and climate forecasting • Climate change and variability • Extent of drought in Zambia
DIVERSIFICATION OF TECHNOLOGY	• The mechanisms in which ZESCO is trying to diversify its technology • Warning system (water availability and drought) • Solar power technology adaptation • Wind power technology adaptation • Thermal power technology adaptation • Infrastructure and materials
LOCATION OF TECHNOLOGY	• The Kafue River Basin • The Congo River Basin • Climatic zone of Zambia • Location of current and future power plants
CAPACITY OF TECHNOLOGY	• Constructions of new power plants • Expansion of the existing power plants • ZESCO's current and expected generation capacity