ASSESSING THE ADAPTIVE CAPACITY OF HOUSEHOLDS TO WATER SCARCITY DURING DROUGHT IN KASALI SUB-COUNTY, KYOTERA DISTRICT, UGANDA

BY

MUKASA JOSEPH

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DECLARATION

This thesis is my original work and has not been submitted in any other university.

Signature: ____________ Date: 14th/07/2020

Mukasa Joseph

This thesis has been submitted to the Institute for Climate Change and Adaptation (ICCA) in partial fulfillment of the requirements for the degree of Masters in Climate Change Adaptation of the University of Nairobi with our approval as supervisors.

Signature: ____________ Date: 26/07/2020

Name of Supervisor 1: Dr. Olaka Lydia

Position: Senior Lecturer, Institute of Climate Change Adaptation

Address: University of Nairobi, PO Box 30197-00100, Nairobi, Kenya

Signature: ____________ Date: 15th/07/2020

Name of Supervisor 2: Dr. Mohammed Said

Position: Associate of the Institute of Climate Change Adaptation

Address: University of Nairobi, PO Box 30197-00100, Nairobi, Kenya

DEDICATION

This work is dedicated to my mother Mrs Noelina Namayanja, my father Mr. George William Ssebuggwawo, my sisters Mrs. Costa Nassuna, Mrs. Divine Nalubiri, my brothers Mr. Mathias Mulumba, Mr. David Kanaabi, Mr. Tomusange Mugagga, Mr. Tadeo Ssebuggwawo and my niece Mr. Pius Zzinga for the support they have given me during my studies. May God bless you.

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ABSTRACT

Approximately 4 billion individuals globally are experiencing water scarcity due to drought. In Uganda about 10% of the population per year experience water scarcity due to drought especially in the south and north-eastern parts of the country. Studies on water scarcity due to drought are required to understand the existing situation in order to develop mitigation and adaptation strategies. The objective of this study is to assess drought and the adaptive capacity of households to water scarcity during drought in Kasali sub-county (SW Uganda). This was done through determining drought trends in a 30-year period (1987-2017), assessing the impact of drought on water availability, determining the adaptation strategies of households to water scarcity and assessing the indicators of adaptive capacity of households to water scarcity. Data on the impact of drought on water availability, adaptation strategies and indicators of adaptive capacity (social resource, infrastructure and institution, financial and economic resource, knowledge and information and technology and innovation) of households to water scarcity was collected using 195 household surveys, two key informant interviews and three focus group discussions. Annual and seasonal (MAM, JJA, SOND and JF) temperature and rainfall components were analysed using regression analysis. Drought values per year were assessed using Reconnaissance Drought Index (RDI) and Standard Precipitation Index (SPI) values calculated using Drought index Calculator (DrinC). The climate results for 1987-2017 show a decrease in the average annual rainfall, MAM and JF seasons, while SOND and JJA seasons show an increase in rainfall trend. Additionally, the average maximum and minimum temperature for annual, MAM, JJA, SOND and JF seasons increased and the increase was statistically significant. Average minimum and maximum temperature increased at a rate of 0.04ºC and 0.02ºC per year respectively. Kasali experienced one extremely dry year and four moderately dry years based on RDI. SPI values show that, 1991-1992 was an extremely dry year, 1988-1989 was a severely dry year and 1999-2000, 2008-2009, 2016-2017 were moderately dry years. Households have few adaptation strategies to water scarcity and their adaptive capacity is moderate. Majority of households in Kasali spend longer time while collecting water in dry years than in wet years. This means that drought has caused a negative impact on water availability in this region. Kyango-Bigavu and Nkenge have a moderate adaptive capacity where are Lwengwe, Kisubi, Kyampigi and Luti has a low adaptive capacity. Kasali generally has a low adaptive capacity. The study recommends provision of early warning information, more water points and adaptation strategies to the households.

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DWAF: Department of Water Affairs and Forestry

FAO: Food and Agriculture Organization

FGD: Focus Group Discussion

GIZ: Gesellschaft fur Internationale Zusammenarbeit

GoU: Government of Uganda

HOA: Horn of Africa

ICA: Infrastructure Consortium for Africa

IHP: International Hydrological Programme

IPCC: Intergovernmental Panel on Climate Change

JJA: June July August

JF: January February

LCMT: Land Conflict Management Tool

LWR: Lutheran World Relief

MAM: March April May

MDB: Murray-Darling Basin

NCDM: National Committee on Disaster Management

NEMA: National Environment Management Authority

NGO: Non-Governmental Organization

NWRS: National Water Resource Strategy

RDI: Reconnaissance Drought Index

SADC: Southern African Development Community

SDG: Sustainable Development Goal

SE: Standard Error

SOND: September October December

SPI: Standard Precipitation Index

PET: Potential Evapotranspiration

UBOS: Uganda Bureau of Statistics

UNESCO: United Nations Educational Scientific and Cultural Organisation

WRM: Water Resource Management

WWAP: World Water Assessment Programme

1.0 CHAPTER ONE: INTRODUCTION

1.1 Introduction

Approximately 4 billion individuals globally are experiencing severe water scarcity (Teklewold *et al*, 2019). This problem has been largely attributed to drought especially in the past decades (Allan, 2011). Water bodies are some of the most delicate ecosystems severely affected by drought especially the rivers (Watts *et al*., 2015). Drought is one of the climate change risks and its severity has risen in recent years. This has led to adverse effects on people's livelihoods (Gleick, 2014; Singh *et al*, 2013). Drought affects the hydrological cycle in form of reduced flow of river streams and reduction in the levels of water in lakes, reservoirs, and groundwater (Smakhtin *et al*., 2004).

Drought is a period of prolonged insufficient amounts of rainfall relative to a multiyear statistical average which leads to a shortage in water in a region for activities, groups or environment sector (NCDM, 2008). Drought is a multifaceted condition and it is defined differently depending on the criterion chosen (FAO, 2013). Four major drought types are identified as, meteorological, agricultural, hydrological and socioeconomic (FAO, 2013). Meteorological drought happens when precipitation deviates to below the long-term normal precipitation. Agricultural drought occurs when the soil moisture becomes insufficient to support and meet a particular crop's need for a given time period. Agricultural drought can be evident after meteorological drought but hydrological drought comes immediately before agricultural drought. The types above are different from hydrological and socio-economic droughts in a way that hydrological drought occurs when there are deficiencies in water supply both on the surface and subsurface. Socio-economic drought occurs when reduced precipitations and availability of water affects human activities. Socio-economic drought links anthropogenic activities with different meteorological elements, hydrological and agricultural droughts (FAO, 2013).

In the past few decades, different parts of the world suffered severe periods of droughts that caused water scarcity. Between 2002 and 2010, Australia suffered an extended period of droughts which affected mostly the river ecosystems especially Australia's largest river system Victoria and Murray-Darling Basin (MDB). This left thousands of people grappling with water scarcity (Leblanc *et al*, 2012). The drought was believed to have been the main cause of global apparent reversal in the intensification of the water cycle that was observed in the previous years (Huntington, 2006).

Russia also experienced the worst drought in the last 38 years in 2010. It caused severe damage to the environment because it was intensive and covered a sizeable area leading to an extensive reduction in water for agriculture production (FAO, 2013). In the US, the southern states were affected by the 2011 drought that affected the water system in Texas, Oklahoma and New Mexico (Nielsen-Gammon, 2011). Other parts of the US affected in the same way included Arizona, Kansas, Arkansas, Georgia, Florida, Mississippi, Alabama, South and North Carolina
(FAO, 2013). China was also affected by drought in 2012 where the drought that started in 2010 entered the third year of devastation especially in the southwestern province of Yunnan (Yang *et al*, 2012). The drought left 2.4 million people with difficulty in accessing drinking water with many households travelling for more than 10km to collect water (FAO, 2013). In the pre-drought period, women (and fewer men) would walk on average a distance varying from 0.5 to 3km depending on the household location (Su *et al*., 2019).

The Greater Horn of Africa (GHOA) and Southern Africa have been pointed out as regions most affected by drought in the last one and half decades (Olufemi, 2017). The HOA is prone to droughts, for example, in the period between 2009 and 2011 it suffered the most severe drought which left millions of people with insufficient water for use leading to a long period of water scarcity (FAO, 2013). Kenya, Somalia and Ethiopia were some of the countries most affected (Dutra *et al*., 2013).

Uganda being in the Greater Horn of Africa (FAO, 2013) has experienced increased drought frequencies and intensities (Aben *et al*., 2012). Between 1991 and 2000, Uganda experienced seven extreme drought episodes all of which affected the water resources, agricultural production at the local level, production of hydropower and overall economy of the country (NEMA, 2010). Climate projections indicate that the conditions in the sub-Saharan countries will become even more severe in the 21st century (Hertel and Rosch, 2010). Therefore, adverse impacts of drought will continue to pose threats to Uganda’s water supply amidst the growing population, their growing demand for water, and increasing urbanization (Kilimani, 2015).

Households need to be safeguarded by boosting their adaptive capacity to access water during drought. This can be ensured through addressing the major pillars of adaptive capacity as pointed out by Deressa *et al* (2010), Gbetibouo (2009), Abaje *et al* (2015) and Sorre *et al*

(2017) which include: income level, infrastructure and institutions, technology and innovation, literacy level and social capital. However, in order to uplift people's adaptive capacity to water scarcity, assessment has to first be done so that there is reliable information about the level of adaptive capacity. This will ensure prioritization of projects geared towards solving the real problem in the community.

1.2 Scope of the Research

The study was conducted in Kasali sub-county, located in Kyotera district, southern Uganda. Among the five parishes (in the sub-county), three were chosen randomly and considered as representative of the sub-county for the study. Drought depends on the amount of precipitation and temperature parameters in an area. The study considered these parameters for determining drought trends and how these trends have affected water availability. The study also examined the adaptation strategies households have developed and how they can be improved. Meteorological drought is the major focus of this study.

1.3 Overview of the Methodological Approach

The study employed two methodological approaches (quantitative and qualitative). Both primary and secondary data were collected. Drought was analyzed using SPI and RDI values calculated by Drought Index calculator (DrinC). Regression analysis was used to analyze temperature and rainfall data for a period of 30 years.

a) Household Survey

Formal surveys were conducted using standard questionnaires administered to the household heads or any other adult found in the household. Data about respondents' family characteristics (family size, sex, age, education, marital status, source of income) as well as information about the indicators of adaptive capacity to water scarcity were gathered.

b) Focus Group Discussion (FGD)

Three focus group discussions were carried out with household members to get information about the indicators of adaptive capacity (income level, infrastructure and institutions, technology and innovation, literacy level and social capital). This was administered by the researcher together with the assistants.

d) Key informant interviews

Additional information from key informants (district environment officer and district agricultural officer) was collected using key informant interviews. The interviews focused on water availability and accessibility strategies to the households in the sub-county, especially during drought.

1.4 Problem statement

Kasali sub-county is an agricultural region with the major food and cash crop being banana and coffee respectively (Ampaire *et al*., 2017). The region consists of wetlands that are the major sources of water supply including Katengo, Kisoma, Kasemugiri and Nakangongo. The increasing climate change related drought has led to most of these wetlands drying up and during prolonged drought, water levels of wells and boreholes constructed around these wetlands fall far below the level required for pumping water which affects households in the parishes of Gayaza, Kigenya, Nkenge, Kyakonda and Buzirandulu that compose Kasali sub-county (Lubinga, 2014). Water levels in some rivers associated with these wetlands also fall as a result of drought. The few water resources available with little water become shared by both people and their livestock (Mubiru, 2010). Water scarcity due to droughts is also known to contribute 21% of the many factors affecting livestock in the region (Mubiru, 2010). The food production has also greatly decreased due to inadequate water for agriculture.

1.5 Research questions

The study was guided by three research questions:

1. What are the frequencies and severity of drought in Kasali sub-county?
2. What is the impact of drought on water availability in Kasali sub-county?
3. What is the adaptive capacity of the households to water scarcity during drought in Kasali sub-county?

1.6 Aim and Objectives

1.6.1 Overall objective

The study aims at assessing drought and the adaptive capacity of households to water scarcity during drought.

1.6.2 Specific objectives

1. To determine the frequency and severity of drought in the past 30 years (from October 1987 to September 2017) in Kasali sub-county.

2. To assess the impact of drought on water availability in households in Kasali sub-county.
3. To determine the adaptation strategies to water scarcity during drought by households in Kasali Sub-county.
4. To establish the indicators of adaptive capacity of households to water scarcity during drought in Kasali sub-county.

1.7 Justification and significance of the Research

The world is warming as a result of greenhouse gas emissions from human activities (anthropogenic) and Uganda is no exception since it has experienced a number of drought seasons (Mubiru, 2010; Trenberth *et al*., 2014). Each year drought in Uganda is expected to affect a bigger population (10%) than floods (0.1%), earthquake (0.03%) and landslide (0.0006%) (World Bank, 2019). A complete assessment of the adaptive capacity to water scarcity during drought in Kasali sub-county is necessary to understand people's ability to adapt to the drought seasons in terms of water availability and accessibility. This is necessary for policy makers and other stakeholders to come up with the best necessary plans (Downing *et al*., 2001). Such plans may include strategies for easy accessibility and availability of water in the region.

The impact of drought on water resources in south and north eastern part of Uganda is likely to increase since climate projections indicate that the conditions will even become more severe in the 21st century (Hertel, 2010; NEMA, 2010). Adverse impacts of drought will continue to pose threats to Uganda's water supply in future amidst the growing population and subsequently their growing demand for water plus the growing economy and increasing urbanization (Kilimani, 2015). This study is also paramount in maintaining clean water and sanitation to the households of Kasali which is one of the SDGs through coming up with adaptation strategies that will continuously supply clean water even during drought to the households for example increase in the number sustainable boreholes, harvesting enough water and having a number of combinations of adaptation strategies. It is also essential to propose methods that will enable supply of water throughout the year in order to improve the economy and reduce poverty levels in the region and prevent hunger related issues especially during drought since the majority of households in Kasali depend on rain fed agriculture (Hirpa *et al*., 2019; Mubiru, 2010).

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

With the climate change effects presently being manifested, adaptation should be a key option (Adger *et al*, 2005). Assessment of adaptive capacity is an embodiment of vulnerability assessment as it is used to identify communities that have fewer resources so that priority is given to such communities during the process of developing better strategies to answer the problem of climate change (Gbetibouo, 2009; Munashe *et al*, 2018). Furthermore, assessment of adaptive capacity to water scarcity is paramount because it indicates the region's potential to withstand adverse effects of climate change and variability. This helps in formulation of strategies to respond to climate change (Gbetibouo, 2009).

Information on the assessment of adaptive capacity helps decision makers at global, national and local level to make appropriate choices aimed at uplifting adaptive capacity of the people (Daffara *et al*, 2010; Juhola and Kruse, 2015). This information is required in Uganda where most regions in the country depend on climate-sensitive sectors like agriculture and the factors that determine the adaptive capacity such as income and education levels are very low.

2.2 Impact of drought on the water resources in Africa

The impact of drought on the hydrological system is less known (Sheffield and Wood, 2008). This is because of the human and physical feedback loops influencing the behavior of the resources at a more local scale (Olufemi, 2017). This still remains a pressing issue which has to be studied because some adaptation strategies to water scarcity may result into maladaptation (Olufemi, 2017). Studies have revealed that approximately 20% of the surface land on earth has ever experienced drought in history. This percentage has risen to 28% and forecasts reveal farther increase of up to 35% by the year 2020 (Sheffield and Wood, 2008). The areas on the planet that have been affected by droughts in the last decade have risen from one percentage to three percentages (Burke *et al*., 2006; Hulme *et al*, 2001).

Drought has increased water scarcity in Sub-Saharan Africa (Olufemi, 2017). Early 2018, Cape Town city of South Africa was hit by one of the worst drought periods in their history which led to water scarcity (Cooney, 2018). During the last months of 2017 in Cape town city, the water reservoirs in the dams dwindled so low to a level that approximately 3.7 million residents of Cape Town city and its surrounding risked experiencing a "Day zero"

situation where residents' taps would be switched off as a way of conserving water (Wolski, 2018).
A number of Southern African countries have been affected by droughts that have exacerbated water scarcity (Olufemi, 2017). According to the report released by Southern Africa Development Community (SADC) in 2016, countries like Lesotho, Swaziland and Zimbabwe had to declare, at a certain point, that drought was a national disaster (Olufemi, 2017) due to the inability of people to access the rightful amount of water for their domestic use as a result of most of the water bodies in those countries drying up. In 2017, some of the South African countries had to declare a partial drought emergency like South Africa and Mozambique as a result of reduced water in those countries (Olufemi, 2017).

In 1990, studies were carried out in South Africa on the impact of drought on groundwater availability especially in rural areas (Calow *et al*., 2002; Robins, 1997). This impact was found to have been worsened by the droughts that occurred in the years between 1991 and 1992 by severely affecting water access among rural people of South Africa. Reports further indicated that in the same period, around 3 million people in Malawi were affected by water scarcity and they resorted to using shallow water sources that were easily contaminated resulting into water-borne diseases like diarrhea, dysentery, and cholera (Calow *et al*., 2010).

Drought events severely affect water levels in reservoirs, for example, the drought that occurred in 2015 in South Africa, led to the reduction in water level of Hazelmere Dam in KwaZulu Natal to 29% capacity as of October 2015. This was the lowest capacity of water level ever reported at this dam. A similar situation was reported on Kamuzu dams in Lilongwe in Malawi were less than 40% of the water level was available as of May 2016 which was the peak of the 2016 drought in Malawi (Olufemi, 2017).

In Malawi still, between 1991 and 1992 drought period, it was realized that drying of shallow water sources for example wells, occurred as an effect of this prolonged drought more so in the southern escarpment and the result was complete water scarcity in these areas (Calow *et al*., 2010). In aquifers that had groundwater, accessibility to such water was a big problem (Calow *et al*., 2002). Studies in Ethiopia have revealed that drought affects boreholes by interfering with the groundwater system. This, in turn affects water accessibility and availability especially in areas where boreholes are the only alternative sources of water during drought. (Calow *et al*., 2010).

Water scarcity due to drought poses the most threat to Uganda especially in areas near Lake Victoria where Kasali is located and over 10% of the Uganda's population is expected to experience water scarcity due to drought per year (World Bank, 2019). Droughts in Uganda are a recurrent hazard and in the years 1967, 1979, 1987, 1999, 2002, 2005, 20008, 2010 and 2017 the country experienced notable events of drought (World Bank, 2019). According to NEMA (2010), the severe droughts that have hit Uganda, affected many water resources in the country. Frequent droughts have been reported in last decades and has drastically changed the landscape especially in the eastern and southern parts of the country (Nsubuga *et al*., 2014). Most of the policies that deal with drought in Uganda focus on short-term solutions to the impact that drought has on water rather than long-term strategies (Kilimani *et al*., 2015).

This is because the real impact that drought has had on water in Uganda and people's capacity to withstand such impacts, has not yet been well studied. This leaves a big gap that this study seeks to bridge through determining the impact that drought has had on water quantity and assessing the adaptive capacity of households to withstand such impacts.

2.3 Water security

Approximately 1 billion people globally cannot have access to better water sources and over 2.6 billion people do not have access to basic sanitation. Most of this population resides in cities of developing countries (UN-Water, 2017). Cities worldwide are challenged by a number of pressures including climate change, population increase, poor urban infrastructure and more. This threatens future cities in providing adequate sanitation and managing scarce water resources (UNESCO, 2016). In many countries, water security is a major hindrance to the development of the economy. High human population impedes the ability to provide enough water resources and the ecosystem service functioning especially in the arid and semi-arid areas (UNESCO, 2016). Water scarcity is therefore one of the major global challenge; it affects food and energy production, ecosystem and human health and it also leads to conflicts and mass migration (Hohenthal and Minoia, 2017). The world is also faced with a decline in the quality of water due to increasing population. Poor water quality affects water consumption, hence resulting into a number of health and environmental hazards which reduces water availability.

Water pollution is also becoming a major threat to freshwater availability (IHP, 2014). Africa finds itself stuck in an ideal storm and faces two major challenges in water security; rapid population growth and climate change. From a net demand perspective, Africa's infrastructure deficit is large. Estimations reveal that Africa requires an investment of over US $ 50 billion each year for the next 30 years to improve water sector (ICA, 2014). Africa is the most vulnerable and most hit by climate change in terms of water security. Water security, is currently a challenge especially at the local as well as national and transboundary level. This has affected indirectly the Energy sector especially hydropower and the food industry since most of the agricultural sector is rain fed. Different governments in Africa are struggling with managing water as a resource (UN-Water, 2017). Whereas extensive utilization and degradation of water resources has been discussed a lot in the Asian context, increasing investment in water development in Africa is getting more attention, with most countries that do not have the human, economic and institutional capacity to develop and manage their water resources in a sustainable way (UN-Water, 2017).

In Uganda, the effects of more and intense droughts, high population growth and the destruction of water catchment areas are causing a fall in the water resources available. The semi-arid northern and north-eastern parts of Uganda are the most affected (Frankel-Reed *et al*., 2011). Mubende, Wakiso and Otuke districts are at a great risk of experiencing drought as over 100,000 people in each of these districts are being affected by water scarcity every year (World Bank, 2019). These present conditions are making the need for effective, climate sensitive water resource management urgent and for water reservoirs for agriculture to be used more efficiently (Frankel-Reed *et al*, 2011). Rapid population growth in Uganda that has almost tripled the global average has put pressure on available water and sanitation services. In the recent studies, 61 percent of Ugandans have no access to clean water and 75 percent have no access to new better sanitation facilities (Agnew and Woodhouse, 2011). Sanitation is still wanting in Kampala where more than 90 per cent of the population depends on local, community sanitation solutions which require fecal sludge management services. The challenge is that these services are not satisfactory especially in the sanitary disposal chain and are neither regulated nor monitored. The situation has been made worse by drought in other parts of the country because it causes water scarcity (Frankel-Reed *et al*., 2011). To achieve water security, education in water use will have to be improved through education for sustainable development at all levels. This involves intensive research on the consequences that drought has on water availability in order to communicate water issues with accuracy and effectiveness.

2.4 Vulnerability to Climate change and variability

Many disciplines, from economics and anthropology, to psychology and engineering, as well as human geography and ecology use the term ‘vulnerability’. A lot of the concepts and definitions scientists use rotate around explaining the lack of adaptive capacity in social and natural systems (Adger, 2003). IPCC (2012), describes vulnerability as; “the degree to which a system is prone to, or is unable to cope with adverse effects of climate change, including climate variability and extremes”. The vulnerability is a function of the nature, size and rate of climate variability of a system, its sensitivity and adaptive capacity. Therefore, susceptibility to climate change in the field of vulnerability of IPCC is a property of the system and a function of exposure, sensitivity and adaptive capacity (Adger, 2003).

According to Adger *et al* (2005) vulnerability is the ability of individual people and communities to cope with external shocks that may affect their livelihood or well-fare. In this context, availability of resources for groups is a major factor of vulnerability. It focuses on the land tenure system as an indicator of adaptive capacity that indicates the extent of access to resources. Households with meager resources and limited access to productive resources are likely to be more affected by climate risks. Also, income and asset disparities render households to become more vulnerable to different risks (Brouwer *et al*, 2007).

The disparity of income and assets put households at various risks and, therefore more vulnerable. Additionally, under climate shocks, and with disparities in income and assets, households become more vulnerable at the collective level, since the collective level is less capable of facing a common shock like floods (Ogallo, 2014). According to Gray (2017), the organization and well-being of people is major factor in vulnerability determination, economic well-being and stability. Age is an important point as the elderly and the young tend to be essentially more sensitive to environmental risk and risk exposure. Generally, populations with low dependency and good health may have the widest range of survival thus they are less vulnerable when they face exposure.

Another study by Zlatko (2018) on coping mechanisms for environmental shocks caused by biophysical vulnerability reveals that factors such as institutional stability and public infrastructure strength are the most important determinants of climate change vulnerability. A well-connected population with inadequate public infrastructure can effectively deal with a hazard and reduce vulnerability. One can say that such a society has a low social vulnerability. Africa is the most vulnerable continent to the effects of climate change due to their national economies largely dependent on natural resources (Eriksen and Kelly, 2007). It is now understood that Africa and especially the poor will be severely affected by climate change due to low adaptive capacity.

Many factors determine the effects of climate change in Africa and limit adaptive capacity. These include poverty, illiteracy, poor infrastructure and institutions, lack of technology and information, limited access to resources, mismanagement and conflicts (Deressa *et al*., 2010).

2.5 Adaptation strategies to water scarcity

The world is still struggling with managing water resource and making sure that people and their environment access the water they need (Global Commission on Adaptation, 2019). This is because of increased drought intensity and frequency (Hirpa *et al*., 2019) hence a need for adaptation to water scarcity. Adaptation to water scarcity strategies basically requires prior preparation and making meaningful decisions from different stakeholders at all levels Ortiz-Bobea *et al*, (2013). In order to design implementable adaptation strategies in communities, efforts have to be put on existing resources that are easily accessible (Shankar, 2018). In many parts of the world, discrepancies between water supply and demand have been solved by storing water during rainy season and later used during the dry seasons. This can either be done by tapping surface water or from roofs. The latter is an easily available strategy for collecting drinking water at a domestic level. Surface water harvesting can as well be used to recharge the underground aquifers either by natural means of soil infiltration or by using artificial methods of water recharge (Mukheibir, 2007). Other methods include increasing water retention capacity which improves and maintains under groundwater that can later be used during periods of water scarcity especially during drought periods (Guyennon *et al*., 2017). Some of these adaptation methods are easy to apply whereas others require skilled knowledge especially those that are more sustainable and this limits less skilled and poor communities from adopting them (Salerno, 2017). Holmes *et al* (2016) also suggested that identifying natural water reservoirs is an important tool for increasing adaptation to water scarcity. Natural water reservoirs like wetlands and flood plains aid in the process of reducing water runoff thereby maintaining water for storage for a long time (Salerno, 2017).

South Africa is one of the country most affected by water scarcity and because of this, a National Water Resource Strategy (NWRS) was developed at a national level which is mandated to address the proper supervision of water resources such that they meet the water demand and development plans of the country. Among the main objectives of this body is to spot areas of water scarcity in the country where there is limited water supply but the development of these areas is constrained by water scarcity. This body also mandates industries drawing water from the country's water resources to provide a water management plan for proper supervision and safeguard of the available water resources in the country (Mwendera and Atyosi, 2018). This is a good strategy for water management and conservation especially in areas or countries with fewer water resources.

Uganda is a least developed country and therefore, all the adaptation strategies have to depend on the economic levels of Ugandan households. In other words, the adaptation strategies employed should be accessible and affordable in order to be sustainable. In research studies about adaptation, it is always paramount to involve the community and themselves suggest the adaptation strategies that are within their means where the government, NGOs and other concerned stakeholders can only improve upon them. This has been lacking in Uganda and this study seeks to bridge this gap.

2.6 Adaptive capacity

The vulnerability of a system to climate change is based on its adaptive capacity, exposure, and sensitivity (Gallopín, 2006; Yohe and Tol, 2002). The concept of adaptive capacity is based on the five major capitals which include human, physical, social, natural and financial capital. There is no need for equilibrium among these capitals because one can be used to uplift the other in case of low levels of the other (Ellis, 2000). The adaptive capacity of the community is likely to be high, when nonfarm sources are added to farm sources because one supplements the other (Ellis, 2000). Villages that have got a variety of income sources and alternative livelihoods have a higher adaptive capacity than those without (Brooks *et al*, 2005).

The impact of climate change can be reduced by increasing peoples' adaptive capacity (Lim & Spanger-Siegfried, 2004). Climate change adaptation is paramount because climate change is already occurring and will continue, therefore, urgency is required in climate change adaptation strategies by governments (Munashe *et al*, 2018). Governments can increase peoples' adaptive capacity through making appropriate policies and decisions in climate change adaptation (Burton *et al*, 2002). This can be limited by inaccurate demographic data from the national data providers (Munashe *et al*., 2018).

With the current situation of climate change and variability in many parts of Uganda, investment in climate change adaptation is needed. This requires adequate study in climate change adaptation because adaptation will ensure appropriate formulation of relevant policies and sustainable actions towards reducing the effects of climate change especially in areas like Kasali sub-county.

3.0 CHAPTER THREE: MATERIALS AND METHODS

3.1 Location and description

The area of study is Kasali sub-county, Kyotera district, southern Uganda (figure 3.1). The sub-county is located between latitudes 31° 33' 0" east and longitudes 0° 37' 0" south. The sub-county has 5 parishes and 37 villages. The parishes include Buziranduulu (7 villages), Gayaza (8 villages), Kigenya (8 villages), Kyakonda (6 villages) and Nkenge (8 villages) (LCMT, 2018). The sub-county sandwiches Kyotera town council.

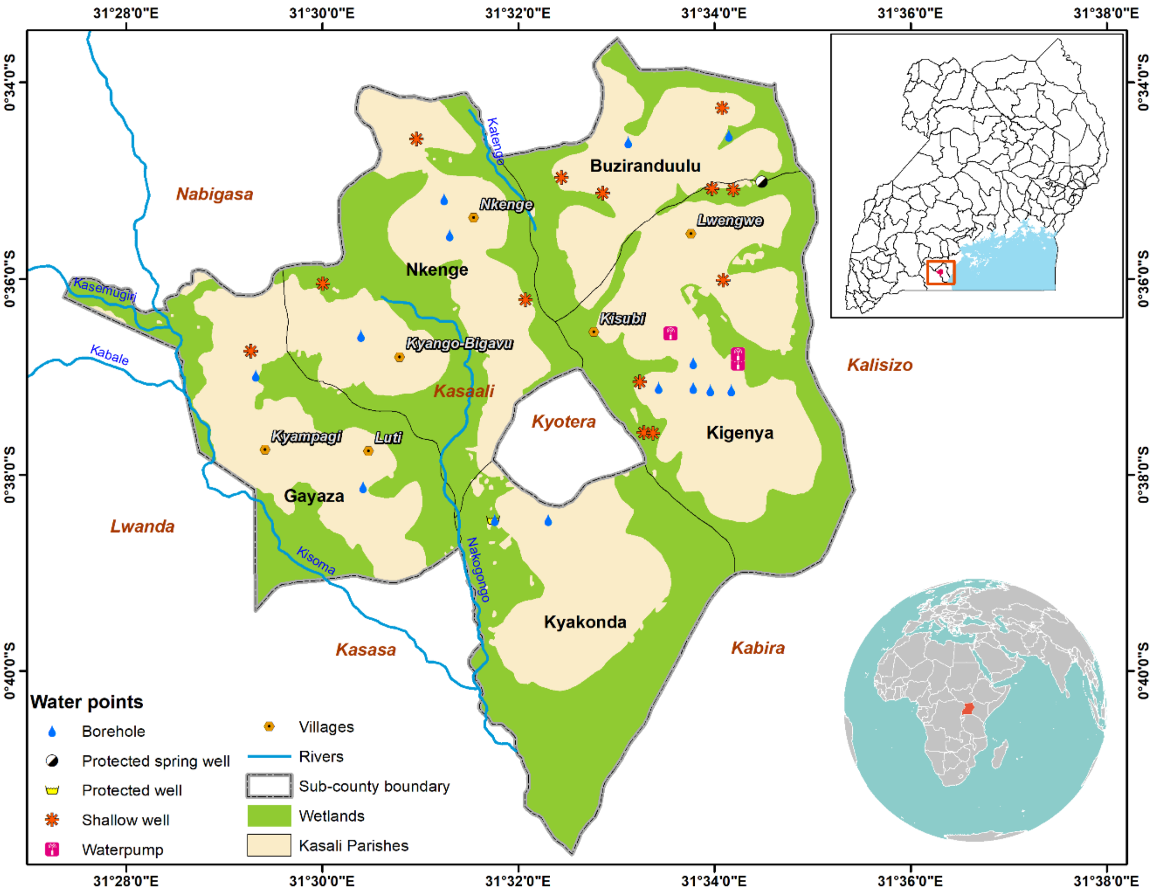


Figure 3.1 Map of Kasali sub-county showing the parishes

Gayaza, Kigenya and Nkenge parishes were selected for the study.

3.2 Biophysical Setting

3.2.1 Climate

Kasali sub-county experiences a moderate rainfall distribution throughout the year with longer rains taking place around March to May and the shorter rains in October and

November receiving a mean annual rainfall of 1,350mm to 2,125mm. January to February and June to August are dry months (GoU, 2013).

The mean annual maximum temperature of Kyotera district is around 25°C. The minimum temperature in the east (17.5°C) is higher than west (15°C) (GoU, 2013). The relative humidity ranges between 80% and 90% in the morning, 61% and 66% in the afternoon for the months of January and May. In June to August, the morning relative humidity decreases to around 77% and the same applies to afternoon which decreases to around 57% (GoU, 2013)

3.2.2 Vegetation

The vegetation of Kasali sub-county can be classified into three major divisions; savannahs, swamps, and forests. Savannah is the most dominant whereas forests are least dominant. The vegetation also varies as much as the different ecosystems that are found in it. The forests are surrounded by savannah grasslands together with swamps (GoU, 2013).

3.2.3 Land uses and Resources

Sixty-eight percent of households own land they cultivate. On the other hand, 84% of households rent land for grazing and 4% of the households use communal land for grazing. Fifty-six percent of households allocate all the land they owned to food production (Kyazze and Kristjanson, 2011; UBOS, 2009).

3.2.4 Physiography and Hydrology

The sub county has a number of considerable physiographic features comprising of plateaus, highlands, hills, flatlands, rivers, lakes and wetlands (NEMA, 2010). Most parts of Kasali have high plateau. It is also characterized by flat-topped hills rising to an average height of about 1300m above sea level. The hills are separated by narrow valleys consisting of papyrus wetlands (GoU, 2013). The major rivers and associated wetlands in the region include Kisoma, Kasemugiri, Nakongongo and Katengo. These are also the major sources of water in the region. These water resources are part of Lake Victoria basin and most of the water end into Lake Victoria, which then leaves through the Owen Falls Dam into Victoria Nile (NEMA, 2010).

3.3 Socio-economic Setting

3.3.1 Local Economic Setting

According to the community information system results of 2009, 37.3% of the population depends on agriculture as the major income source, 2.2% trade, 0.6% manufacturing, 3.3% services, and 48.7% other non-formal activities. However, each individual at least practices agriculture on a subsistence scale alongside other sources of income making agriculture the most practiced economic activity in this sub-county (UBOS, 2009).

The crops most grown include coffee and banana. Others include beans, maize, sweet potatoes, cassava, sorghum, tomatoes, cabbages, Irish potatoes, groundnuts, cowpeas, yams, rice, sugar cane, and onions. Some fruits like mangoes, passion fruits, pineapples, and oranges are also grown on a subsistence scale. The animals most reared include chicken followed by pigs, goats, and cattle in that order (UBOS, 2009).

3.3.2 Social Setting

Kasali sub-county has a total population of 25,700. 49% of the population are male and 51% are females (UBOS, 2009). This means that females are the majority in this sub-county. Of the total population, 81.9% are under 35 years of age and 18.1% are 35 years and above. This means that the sub-county is mainly composed of youths (UBOS, 2009).

3.3.3 Health Setting

There are private and public health centers in the sub-county. Private health centers are located in the villages and they handle less complicated health cases. A public hospital is located at the headquarters of the sub county. This handles complicated health cases (GoU, 2013). The health setting of Kasali is relevant in handling cases of water borne diseases especially during drought when water is inadequate foe households. However, having only one public health center for the entire sub-county is not enough to handle cases of the households' members especially during drought amidst the poverty levels in the region.

3.4 Materials and methods

3.4.1 Conceptual framework

Climate change and variability results in increased floods and recurrent drought. Drought affects water catchment areas like forests and natural water resources like rivers, lakes, wells and wetlands. The forests may be affected through drying of trees or vegetation as a result of excessive evapotranspiration which may lead to wild fires. Natural water resources may be affected through drying up due to increased evapotranspiration and reduced precipitation. This results into reduced water in the community hence water scarcity. Water scarcity is likely to affect the most vulnerable households and therefore in response they come up with adaptation strategies. However, these will depend on their potential, policy responses by the government and support from stakeholders like NGOs, government and others. Stakeholders' engagement will improve adaptive capacity to water scarcity by the households through provision of water conservation mechanisms, livelihood improvement, sustainable water projects, and employment opportunities among others. Therefore, this study followed the above framework through assessing drought for a 30-year period, its impact on water availability, adaptation strategies and the adaptive capacity of households to water scarcity during drought. The outcomes will improve the adaptive capacity of the households. The independent variable in this framework is the drought due to climate change and household water scarcity is the dependent variable. The figure is presented in figure 3.2.

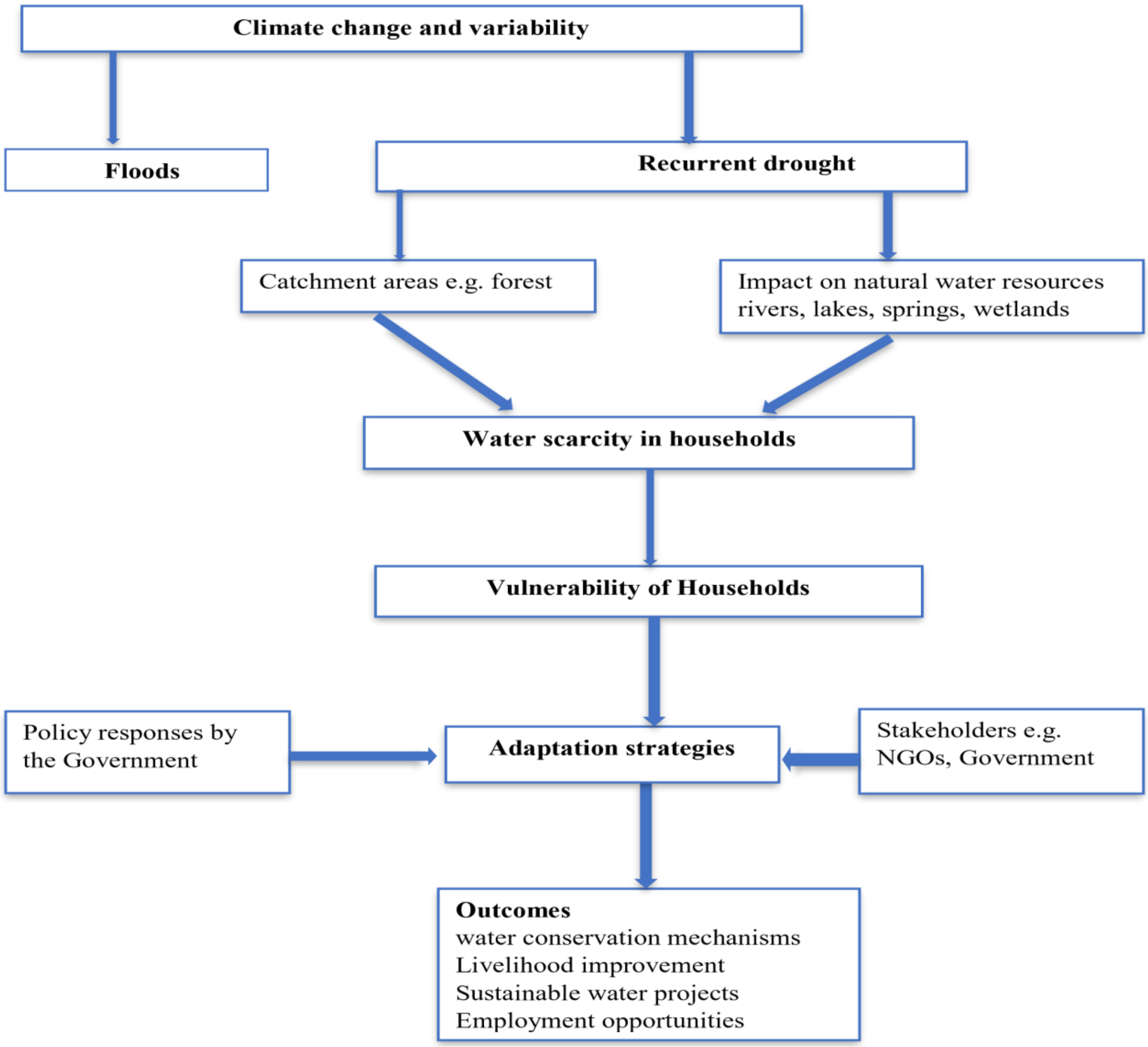


Figure 3.2 Conceptual Framework

3.4.2 Method for Objective one

Objective one: To determine the frequency and severity of drought in the past 30 years (from October 1987 to September 2017) in Kasali sub-county.

Monthly precipitation and maximum and minimum temperature data for October 1987 to September 2017 for Kasali sub-county was acquired from Uganda National Meteorological Authority (UNMA). Drought trend was analyzed using Standard Precipitation Index (SPI) and Reconnaissance Drought Index (RDI).

3.4.2.1 Reconnaissance Drought Index (RDI)

RDI requires precipitation and Potential Evapotranspiration (PET) data. Using Hargreaves's method, PET was calculated using the minimum and maximum monthly temperature

(Tigkas, Vangelis and Tsakiris, 2015). Data from October 1987 to September 2017 was prepared using Microsoft excel before being entered into the Drought Index Calculator (DrinC). The initial RDI value was calculated using Equation 3.1.

$$\gamma_0^r = \frac{\sum_{h=1}^{12} P_{rh}}{\sum_{h=1}^{12} PET_{rh}}, r = 1:N, h = 1:12 \text{ ……………………………Equation 3.1}$$

Where; $\gamma_0^r = innitial\ value\ of\ RDI$

$r = Month$

$h = Year$

$P = precipitation$

$PET = Potential\ Evapotranspiration$

$N = Number\ of\ years\ with\ statistics$

$P_{rh} = Precipitation\ value\ of\ the\ month\ r\ in\ the\ hydrological\ year\ h$

$PET_{rh} = Potential\ evapotranspiration\ of\ the\ month\ r\ in\ the\ hydrological\ year\ h$

RDI for different years was calculated using equation 3.2.

$$RDI_n^r = \frac{\gamma_0^r}{\bar{\gamma}_0} - 1 \text{ ………………………………………………………Equation 3.2}$$

Where; $\bar{\boldsymbol{\gamma}}_0$ is the mean value of $\boldsymbol{\gamma^r}_0$ for different years.

The standardized RDI_{st} is calculated using $\gamma_0{}^r$ values for different years using equation 3.3

$$RDI_{st}^r = \frac{a^r - \bar{a}}{\delta_y} \text{ …………………………………………………………….Equation 3.3}$$

Where $a^r = \ln \boldsymbol{\gamma_0^r}$, $\bar{\mathbf{a}}$ is the mean of a^r and δ_y is the standard deviation of a^r

3.4.2.2 Standard precipitation index (SPI)

The SPI was also applied to analyze the trend and magnitude of drought. The precipitation record from October 1987 to September 2017 was used to calculate SPI values. This 30-year period record was tailored to a probability distribution function and then transformed into a normal distribution in order to bring the desired period and the mean SPI of the study area to zero (Edwards and McKee, 1997). To calculate the SPI, precipitation difference is taken from the mean for any given time period. It is then divided by the standard deviation using equation 3.4.

$$SPI = \frac{(X_{in} - X_i)}{\delta_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ Equation 3.4}$$

Where X_i =Mean precipitation for i^{th} station

X_{in} =Precipitation for i^{th} station and n^{th} observation

δ_i =Standard deviation for the i^{th} station

SPI values may either be positive or negative and the positive values are more than the median and the negative values are below the median precipitations. SPI is typically used to monitor intensity and length of the drought event much as it can also be used to monitor wet periods. The gamma distribution defined by its probability distribution function (pdf) as shown in equation 3.5;

$$g(x) = \frac{1}{\beta^{\omega}\Gamma(\omega)} x^{\omega-1} e^{-x/\beta} \quad for\ x > 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 3.5}$$

Where ω and β are parameters for shape and scale respectively,

$\Gamma(\omega)$ is the gamma function and

x is precipitation.

The estimations of gamma pdf parameters ($\omega\ and\ \beta$) for each time scale and station are determined using equation 3.6.

$$\omega = \frac{1}{4W}\left(1 + \sqrt{1 + \frac{4W}{3}}\right), \beta = \frac{\mu}{\omega}, where\ W = ln(\mu) - \frac{\sum ln\ \mu}{n}; \text{ .... Equation 3.6}$$

Where; n is the number of observations.

The cumulative probability is then calculated from the parameters above for the particular month and time scale and for the unknown location. Since the gamma function for $x = 0$ is undefined, and the distribution of precipitation may be composed of zeros, the cumulative probability will be calculated using equation 3.7.

$$A(x) = p + (1 - p)H(x) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Equation 3.7}$$

Where; p is the probability of zero precipitation *(x)* is the cumulative probability of the incomplete gamma function. Assuming y is the number of zeros in the precipitation time scale, estimation for p can be given by $\frac{y}{n}$, *H(x)*, can be standardized to the normal random variable *z* having a mean as zero and one as variance (Kumar *et al*, 2009) which gave us the

SPI value. To identify a drought event according to the SPI, the index moves continuously up to an intensity of -1.0 or below and the event stops when the index becomes positive. The interpretation of the SPI values is shown in table 1 below (Tigkas et al, 2015)

Table 3.1 Drought classification according to SPI and RDI

SPI/RDI values	**Classification**
2.00 +	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
-2.00 and less	Extremely dry

Source: Jang, 2018

3.4.3 Methods for Objective 2 and 3

Objective 2: To assess the impact of drought on water availability in households in Kasali sub-county.

Objective 3: To determine the adaptation strategies to water scarcity during drought by households in Kasali Sub-county.

Data for these objectives was collected using household surveys, standard questionnaires, focus group discussions (FGDs) and key informant interviews (KII).

a) Household Survey

The sample size to administer the standard questionnaires was determined using the Cochran equation. Cochran's equation allows to calculate an ideal sample size given the desired level of precision, confidence level and estimated proportion of attributes present in the population (Godden, 2004). Since the population of Kasali sub-county is large, equation 3.8 was adopted to acquire a representative sample size.

$$n_0 = z^2 p \frac{(1-p)}{e^2}$$

Where $\boldsymbol{n_0}$ = Sample size

$\boldsymbol{z}$ =Value (1.96 for 95% confidence level)

$\boldsymbol{p}$ = Estimated proportion of population (assumed to be 50% or 0.5)

$\boldsymbol{e}$ = Margin of error (assumed to be 0.07)

Therefore $n_0 = \frac{1.96 \times 1.96 \times 0.5(1-0.5)}{0.0049}$

$$n_0 = 196$$

$$Adjusted\ Sample\ (S) = \frac{n_0}{1 + \left(\frac{n_0 - 1}{P}\right)}$$

Where:P is the population of Kasali Sub County given by 25,700.

$$Adjusted\ sample(S) = \frac{196}{1 + \left(\frac{196 - 1}{25700}\right)}$$

$$Therefore\ adjusted\ sample(S) = 195$$

The standard questionnaires were composed of both the qualitative and quantitative parts (Appendix 1). The qualitative part collected data on the adaptive strategies of households to water scarcity and impact of drought on water availability. The questionnaires were administered to the household heads or any other adult found in the household. Three parishes were selected at random and in each parish two villages were selected making a total of six villages. Household surveys (33) were carried out in Nkenge, Kyampigi and Kyango-Bigavu and 32 in Kisubi, Lwengwe and Luti making a total of 195 households surveys. The questionnaires were administered proportionally in the selected villages. The list of all the households in different villages was identified through collaboration with the respective local council leaders (village leaders).

b) Focus Group Discussion (FGD)

Three focus group discussions were conducted one in each of the selected parishes. Each focus group discussion comprised of five women, five men and five youths with at least one person of each class of people coming from a different household and these were organized by the help of the local council administrators for the respective villages. Each discussion was administered by the researcher with the help of two research assistants and mainly aimed at collecting information about the impacts of drought on water availability and the adaptation strategies adopted by households to reduce the impact of water scarcity. The discussions were guided by structured questions (Appendix 2).

c) Key Informant Interview

This was used to collect additional data from the district environment officer and the district agricultural officer. The interviews focused on water availability strategies by different households in the sub-county especially during drought seasons and were structured by the use of guided questions (Appendix 3). These interviews also enabled to cross-check the respondents' information from the villages. This data was analyzed using Microsoft-Excel 2016. The results are presented in chapter 4.

3.4.4 Method for Objective 4

Objective four: To establish the indicators of adaptive capacity of households to water scarcity during drought in Kasali sub-county.

The quantitative part of the questionnaires composed of a five-point Likert scale. The five point Likert scale is a psychometric response where participants specify their level of agreement to a statement in five points (Joshi *et al*, 2015). This scale was used to collect data on the indicators of adaptive capacity to water scarcity in the households. The scale ranking is from 1 to 5 where 1=strongly disagree, 2=disagree, 3=undecided, 4=agree and 5= strongly agree. The main indicators influencing the adaptive capacity of households to water scarcity during drought were selected by adopting the methodology also used by Deressa *et al*., (2010); Gbetibouo (2009), Abaje *et al*. (2015) and Sorre *et al*. (2017) and these included: financial and economic resource (FE), infrastructure and institutions (II), technology and innovation (TI), Knowledge and information (KI) and social resource (SR). The adaptive capacity (AC) of each selected village was calculated using equation 3.10

$$AC = \frac{KI + II + TI + FE + SR}{5}$$

Where:

KI =Knowledge and information resource

II =Infrastructure and institutions resource

TI =Technology and innovation resource

FE =Financial and economic resource

SR =Social resource

With the interval of 0.5, the upper cut off point was determined as 3.00+0.5=3.50 and lower limit as 3.00-0.5=2.50 (Abaje *et al*., 2015). Table 3.2 is the reference in the classification of the adaptive capacity of the households where 0.0-2.49 is low adaptive capacity, 2.50-3.49 is moderate adaptive capacity, 3.50-5.00 is high adaptive capacity.

Table 3.2 Classification of Adaptation Capacity

Mean Score	Level of Adaptive Capacity
0.00 – 2.49	Low adaptive capacity
2.50 – 3.49	Moderate adaptive capacity
3.50 – 5.00	High adaptive capacity

Source; **Abaje *et al*, 2015**

4.0 CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Objective one: Trend and occurrence of drought from October 1987 to September 2017 in Kasali sub-county.

4.1.1.1 Introduction

This section presents the results of the rainfall and temperature patterns for the 30-year period together with drought analysis based on. Reconnaissance Drought Index(RDI) and Standard Precipitation Index (SPI). The two indices were used to identify the number of dry and wet years in the 30-year period.

4.1.1.2 Rainfall and temperature patterns

The average monthly rainfall for the period 1987 to 2017 for Kasali is shown in figure 4.1. The results show that Kasali sub-county has a bimodal rainfall distribution; long rains that start from March to May (MAM) and short rains that start from September to December (SOND). It also experiences two dry seasons one occurring in June-July-August (JJA) and the second in January to February (JF). May is the wettest month and receives the highest amount of rainfall averaging 178.43 mm (SE ±12.33) and the driest month is July with a long-term average rainfall estimated at 27.15 mm (SE ±3.6).

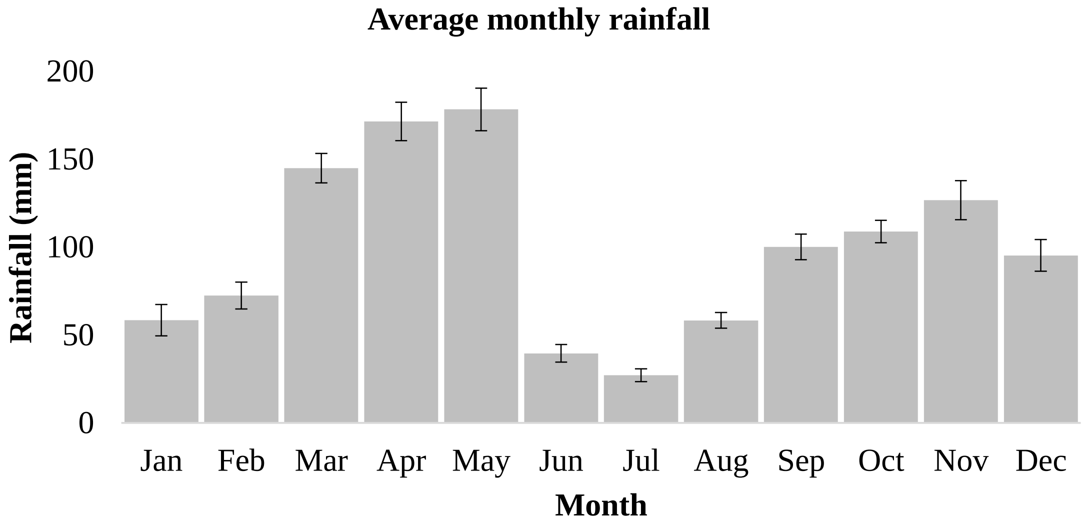


Figure 4.1 Long-term average monthly rainfall for Kasali sub-county (1987-2017)

Temperature

The average monthly minimum and maximum temperature for the 30-year period (1987-2017) for Kasali sub-county is shown in Figure 4.2. April and May experienced highest minimum temperature of 17.1°C each. The coldest month is July with a minimum temperature of 15.6°C. The overall monthly minimum temperature was 16.5°C. February is the hottest month with an average temperature of 29.0 °C. May experienced lowest maximum temperature of 27.4 °C also its when the rainfall was at its peak. The overall monthly average maximum temperature for Kasali sub-county was 28.0 °C.

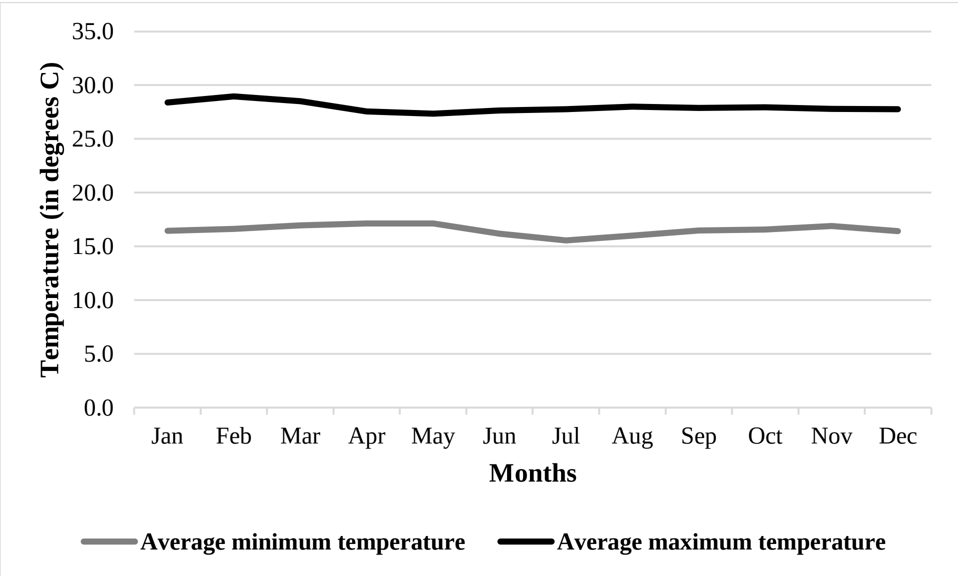


Figure 4.2 Long-term monthly average minimum and maximum temperature for Kasali sub-county (1987-2017)

Table 4.1 shows long-term trends in the rainfall, maximum and minimum temperature. The results indicate that the annual, MAM and JF rainfall was declining but not statistically significant. JJA and SOND had an increase in rainfall which was not statistically significant. There is an increase in annual, MAM, SOND, JJA and JF maximum and minimum temperature. The increase for annual, SOND, JJA and JF was statistically significant while for MAM, the increase in minimum temperature was not statistically significant (Table 4.1).

Table 4.1 Trends in rainfall, maximum and minimum temperature for Annual, MAM, JJA, SOND, JF seasons for the period of 1987 to 2017.

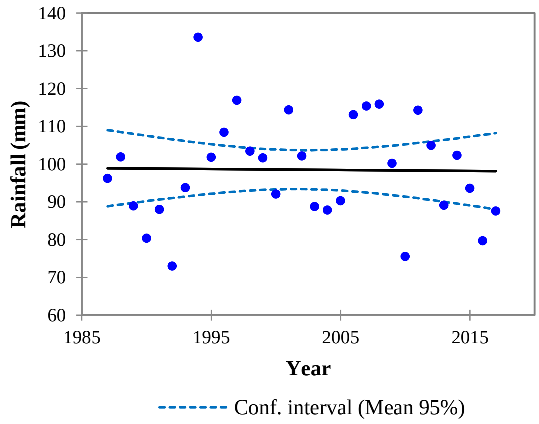
	Rainfall		Max Temperature		Min Temperature	
Period	tau	p-value	tau	p-value	tau	p-value
Annual	-0.024	0.8650	0.345	0.0087	0.493	0.0001
MAM	-0.030	0.8251	0.326	0.0121	0.326	0.0708
JJA	0.079	0.5406	0.452	0.0005	0.388	0.0031
SOND	0.105	0.4146	0.314	0.0166	0.505	0.0000
JF	-0.135	0.2919	0.272	0.0370	0.380	0.0032

Table 4.2 and figure 4.3 show the historical changes in the annual and seasonal rainfall components over Kasali sub-county for 1987 to 2017 based on the regression analysis. The annual rainfall shows declining trends but not statistically significant (p = 0.865). There was a decline in rainfall for the MAM and marginal increase in JJA but both were statistically not significant. The rains of SOND in Kasali showed a significant increase at p <0.5 and the dry season of JF showed a significant decline in rainfall (p= 0.291) over the years.

Table 4.2 Rainfall trend for Kasali sub-county (1987-2017) based on regression analysis

	Intercept	SE	Slope	SE	F-test	r-squared	p Value
Annual	152.95	565.458	-0.027	0.282	0.009256	0.0003	0.865
MAM	823.47	1487.765	-0.328	0.743	0.19588	0.0067	0.825
JJA	- 307.46	670.347	0.174	0.335	0.271356	0.0093	0.541
SOND	- 586.89	1014.335	0.347	0.507	0.469081	0.0159	0.415
JF	1317.50	1430.527	-0.625	0.715	0.765916	0.0257	0.292

a) annual rainfall



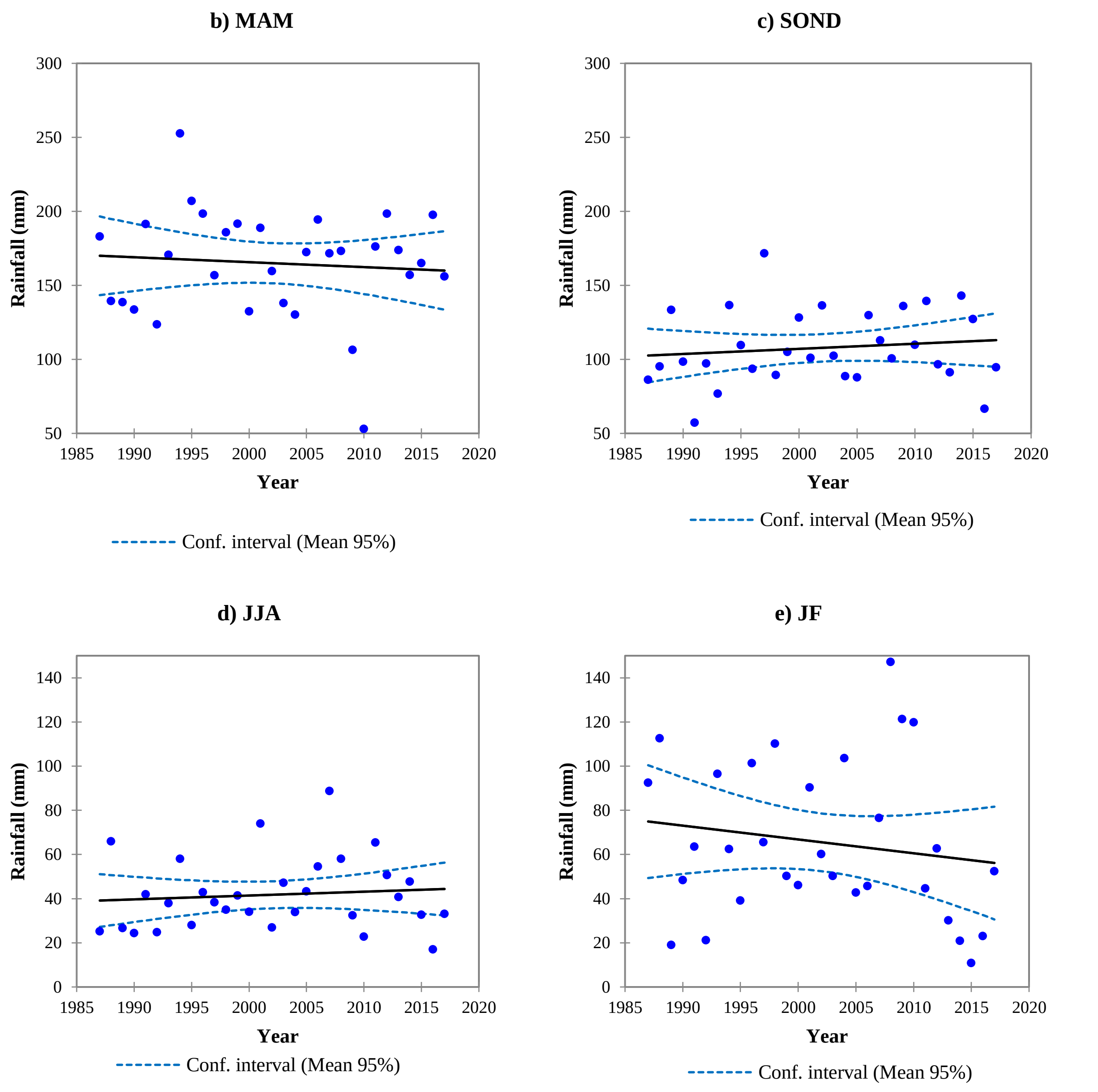
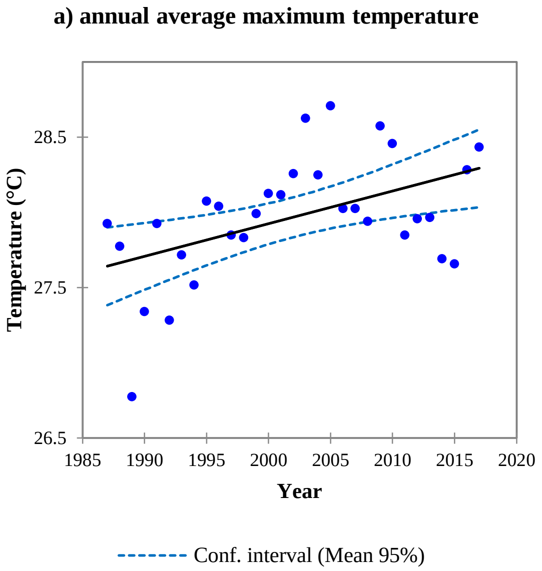


Figure 4.3 Annual and seasonal average rainfall trends for Kasali sub-county (1987-2017).

The middle line in the graph shows the line of best fit between year and rainfall and the upper and lower lines show the upper and lower confidence intervals around the predictions respectively.

Figure 4.4 shows the annual minimum and maximum temperature trends for the period of 1987-2017 in Kasali sub-county. The results showed a statistically significant increase in the average annual maximum and minimum temperature at $p<0.5$ (Table 4.3 and Table 4.4). The increase in the minimum temperature was higher than the increase in maximum temperature. The annual average minimum temperature increased by 1.2°C while the annual maximum average temperature increased by 0.7°C (Table 4.5). This means that the annual maximum temperature in Kasali sub-county has been warming by 0.02 per year and 0.2 per decade. In a similar way, the annual average minimum temperature has been increasing at by 0.04 per year and 0.4 per decade.



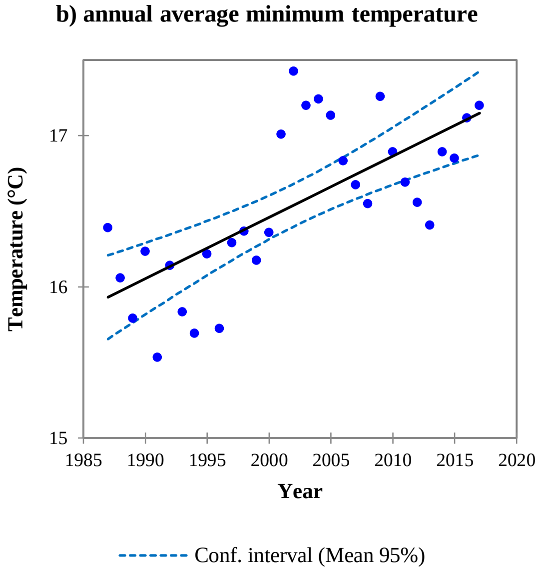


Figure 4.4 Average annual maximum and minimum temperature trends for Kasali sub-county (1987-2017)

The middle line in the graph shows the line of best fit between year and temperature and the upper and lower lines show the upper and lower confidence intervals around the predictions respectively.

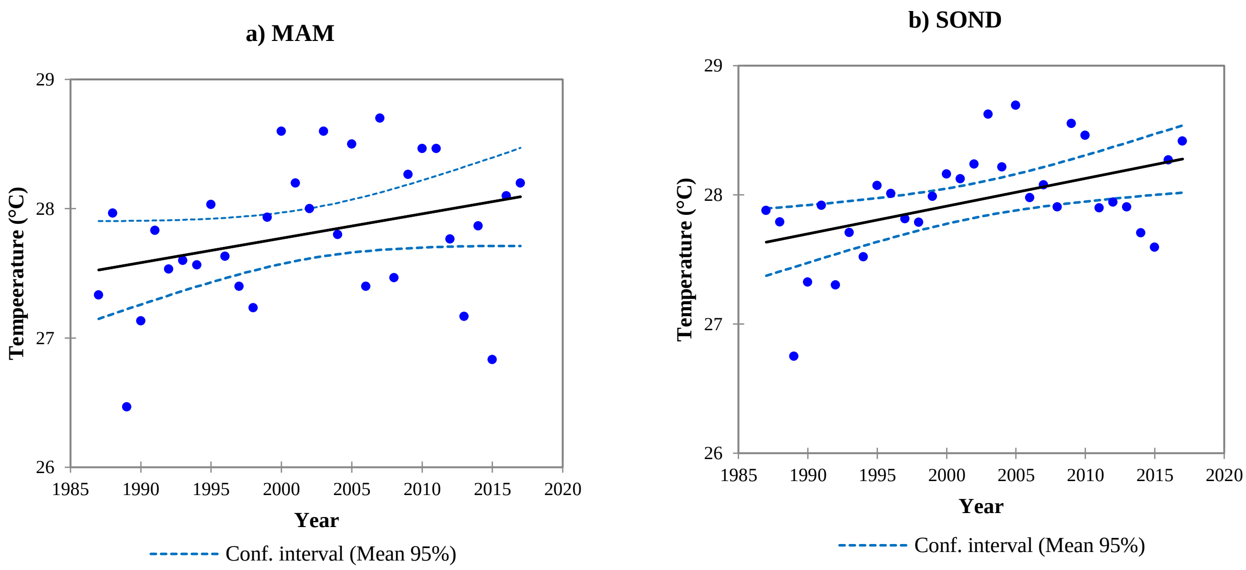
Table 4.3 Minimum temperature for Kasali sub-county (1987-2017) based on regression analysis

	Intercept	SE	Slope	SE	F-test	r-squared	p Value
Annual	- 15.476	14.5187	0.0217	0.0073	8.9539	0.236	0.0087
MAM	- 9.917	81.5870	0.0188	2.9333	3.1602	0.098	0.0121
JJA	- 27.192	17.8260	0.0275	0.0089	9.5202	0.247	0.0005
SOND	- 15.069	14.6477	0.0215	0.0073	8.6287	0.229	0.0166
JF	- 49.426	27.3068	0.039	0.0136	8.1808	0.220	0.0370

Table 4.4 Maximum temperature for Kasali sub-county (1987-2017) based on regression analysis

	Intercept	SE	Slope	SE	F-test	r-squared	p Value
Annual	- 17.316	-17.3162	0.0226	0.0226	9.9604	0.256	0.0001
MAM	-54.610	22.4396	0.0358	0.0112	10.2054	0.260	0.0707
JJA	- 56.327	17.6481	0.0361	0.0088	16.7603	0.366	0.0031
SOND	- 67.649	15.6039	0.0421	0.0078	29.1722	0.501	0.0000
JF	- 84.407	30.3851	0.0504	0.0152	11.0377	0.276	0.0032

Figure 4.5 and figure 4.6 show seasonal average maximum and minimum temperature trends respectively for Kasali (1987-2017). The results show that there is a statistically significant increase in the average minimum and maximum temperature for MAM, JJA, SOND and JF in the period of 1987-2017 for Kasali sub-county at $p<0.5$ (Table 4.1). The highest increase in the maximum temperature was registered in JF (1.1°C) and lowest in MAM (0.6°C). The minimum temperature increase was highest in JF (1.5°C) and lowest in MAM (1.1°C) (Table 4.5).



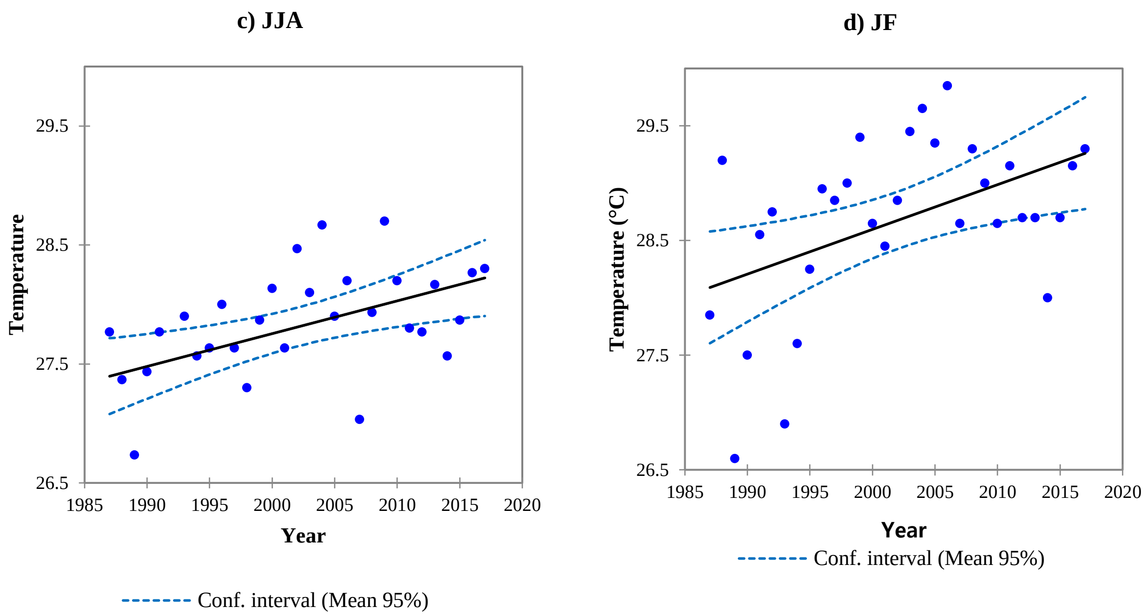
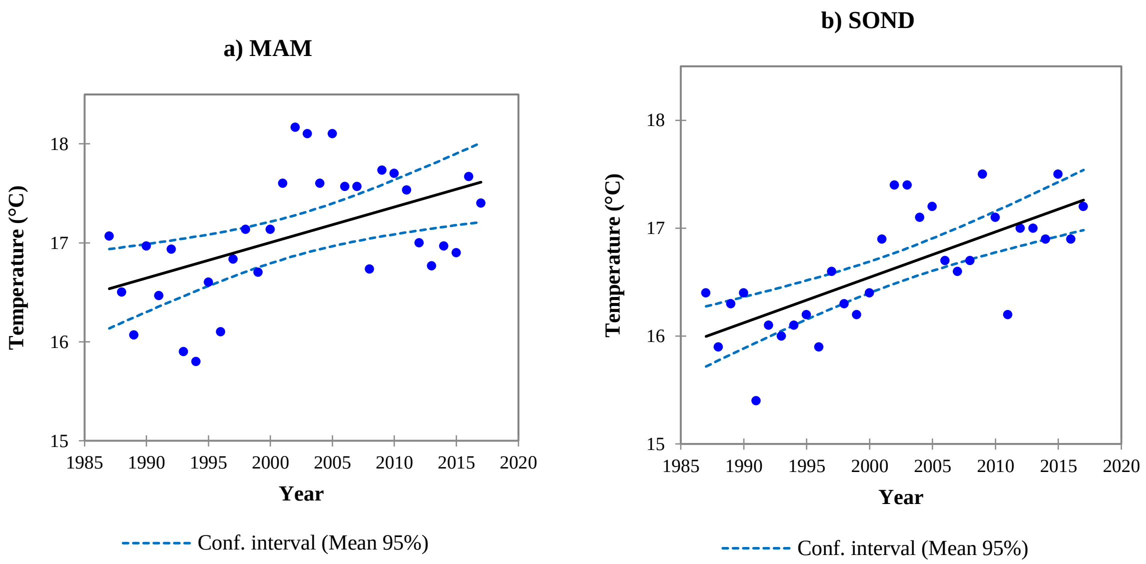
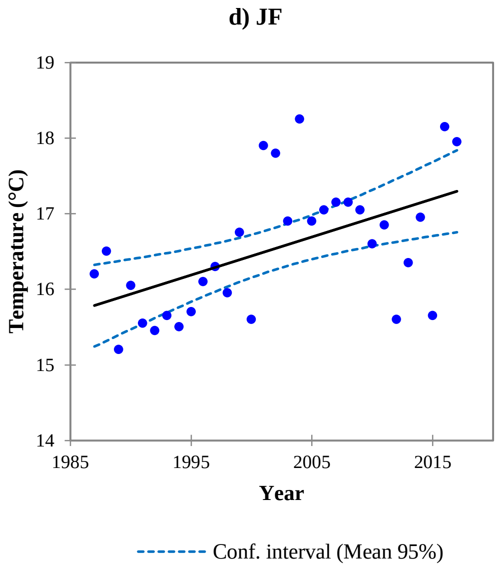


Figure 4.5 Seasonal average maximum temperature for Kasali sub-county (1987-2017)





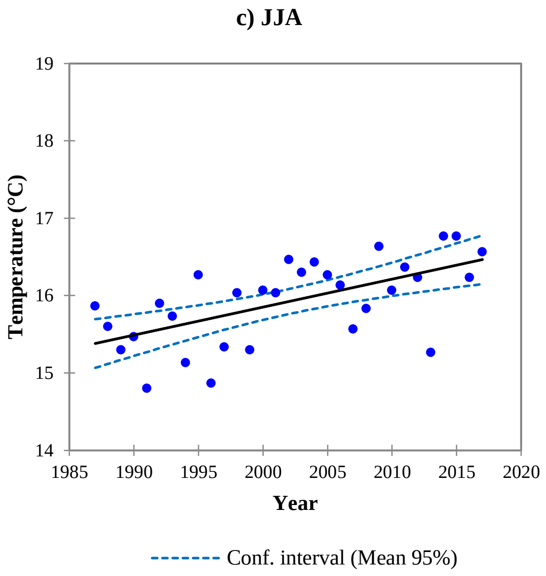


Figure 4.6 Seasonal average minimum temperature trends for Kasali sub-county 1987-2017.

The middle line in the graph shows the line of best fit between year and minimum temperature and the upper and lower lines show the upper and lower confidence intervals around the predictions respectively.

Table 4.5 Summary of maximum and minimum temperature changes in Kasali sub-county for the period of 1987-2017.

	Season	Year	Degree (^{0}C)	Change (^{0}C)
Maximum	Annual	1987	27.6	0.7
		2017	28.3	
	MAM	1987	27.5	0.6
		2017	28.1	
	JJA	1987	27.5	0.8
		2017	28.3	
	SOND	1987	27.7	0.7
		2017	28.3	
	JF	1987	28.1	1.1
		2017	29.2	
Minimum	Annual	1987	15.9	1.2
		2017	17.1	
	MAM	1987	16.5	1.1
		2017	17.6	
	JJA	1987	15.4	1.2
		2017	16.5	
	SOND	1987	16.0	1.3
		2017	17.3	
	JF	1987	15.7	1.5
		2017	17.2	

4.1.1.3 Drought classification based on Standard Precipitation Index (SPI)

SPI and RDI drought classification is shown in table 4.6 where 2.0 and above, 1.5 to 1.99, 1.0 to 1.49, -0.99 to .99, -1.0 to -1.49, -1.5 to -1.99, and -2 and less are classified as extremely wet, very wet, moderately wet, near normal, moderately dry, severely dry and extremely dry respectively.

Table 4.6 Drought classification using to Standard Precipitation Index and Reconnaissance Drought Index

SPI and RDIst values	Drought
2.00 +	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
-0.99 to 0.99	Near normal
-1.00 to -1.49	Moderately dry
-1.50 to -1.99	Severely dry
-2.00 and less	Extremely dry

Source: Jang, 2018

Figure 4.7 shows the Standard Precipitation Index (SPI) values from 1987 to 2017. The SPI values ranged from -2.50 to 2.03. It can be observed that there was one year (1997-1998) in the category with SPI value above +2.00 (extremely wet), one year (2000-2001) with SPI between +1.50-1.99 (very wet) and two years (2006-2007, 2007-2008) with SPI value between 1.00-1.49 (moderately wet). There were twenty-one years (1987-1988, 1989-1990, 1990-1991, 1992-1993, 1993-1994, 1994-1995, 1995-1996, 1996-1997,1998-1999, 2001-2002, 2002-2003, 2003-2004, 2004-2005, 2005-2006, 2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016) with SPI values between -0.99-0.99 (near normal), three years (1999-2000, 2008-2009, 2016-2017) with SPI values between -1.00 to -1.49 (moderately dry), one year (1988-1989) with an SPI value between -1.5 to -1.99 (severely dry) and one year (1991-1992) with an SPI value of above -2.00 (extremely dry).

The year 1991-1992 had the highest negative SPI (-2.50) (extremely dry) whereas 1998-1999 had the lowest negative SPI value (-0.04) (near normal). On the other hand, 1997-1998 has the highest positive SPI value (2.03) (extremely wet) and 2012-2013 had the lowest positive SPI (0.03) (near normal). In the last four years (2013-2014, 2014-2015, 2015-2016, 2016-2017), there were three years with negative indices (2013-2014, 2014-2015 and 2016-2017), with 2016-2017 having an SPI value of -1.15 (moderately dry) whereas the other two years (2013-2014 and 2014-2015) had SPI values of -0.48 (near normal) and -0.77 (near normal) respectively. Only one year (2015-2016) had a positive SPI value of 0.29 (near normal). This means that the drought trend in the last four years tend towards extreme drought.

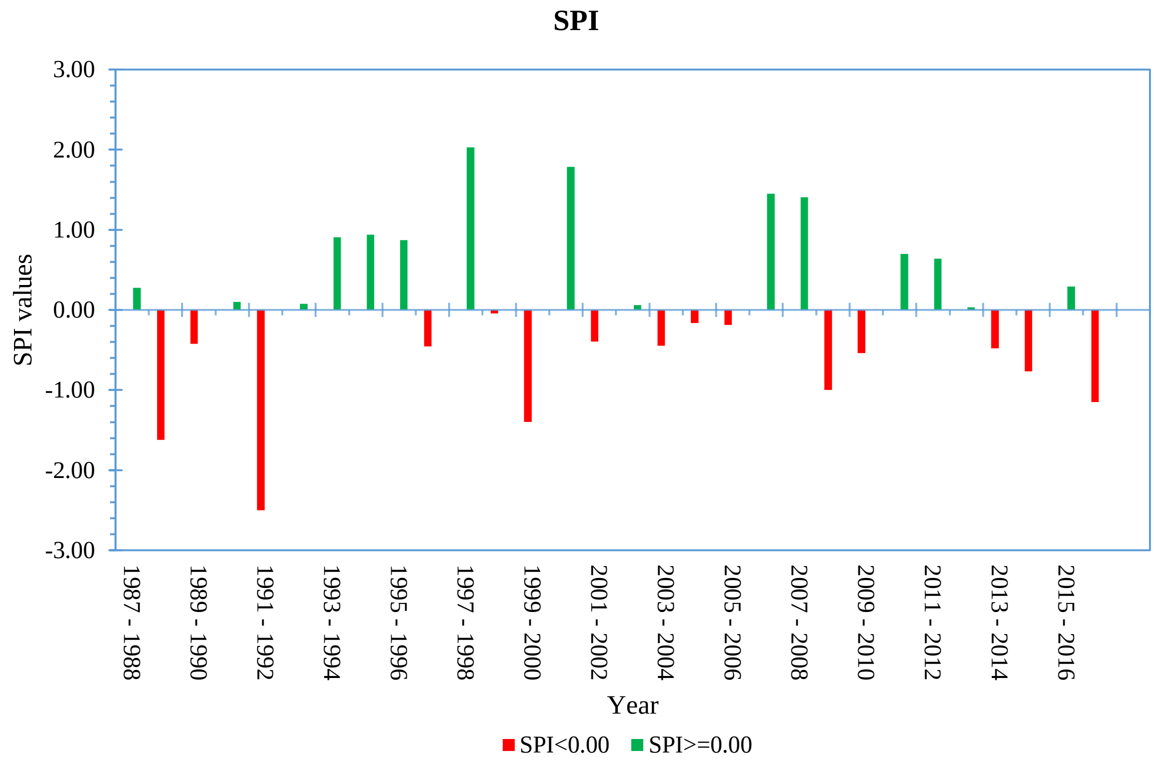


Figure 4.7 Standard Precipitation Index (SPI) for Kasali sub-county from 1987 to 2017

4.1.1.4 Drought classification based on Reconnaissance Drought Index (RDIst)

From figure 4.8, it can be observed that there was one year (1997-1998) with an RDI above +2.00 (extremely wet) two years (2000-2001 and 2006-2007) with RDI between +1.50-1.99 (very wet) and one year (2007-2008) with RDI value between 1.00-1.49 (moderately wet). There were twenty-one years (1987-1988, 1989-1990, 1990-1991, 1992-1993, 1993-1994, 1994-1995, 1995-1996, 1996-1997,1998-1999, 2001-2002, 2002-2003, 2003-2004, 2004-2005, 2005-2006, 2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016) with an RDI values between -0.99-0.99 (near normal), four years (1988-1989, 1999-2000, 2008-2009, 2016-2017) with RDI values between -1.00 to -1.49 (moderately dry), no year that had an RDI value between -1.5 to -1.99(severely dry). There was one year (1991-1992) with an RDI value of above -2.00 (extremely dry).

The year 1991-1992 had the highest negative RDI (-2.50) (extremely dry) whereas 2004-2005 had the lowest negative RDI value (-0.13) (near normal). On the hand, 1997-1998 had the highest positive RDI value (2.07) (extremely wet) and 1990-1991 had the lowest positive RDI (0.03) (near normal). In the last four years (2013-2017), there were three years with negative indices (2013-2014, 2014-2015 and 2016-2017). 2016-2017, 2013-2014, 2014-2015 and 2015-2016 had an RDI value of -1.15 (moderately dry), -0.48 (near normal), -0.77 (near normal) and 0.29 (near normal) respectively. This means that the trend in drought in the last four years was towards extreme drought.

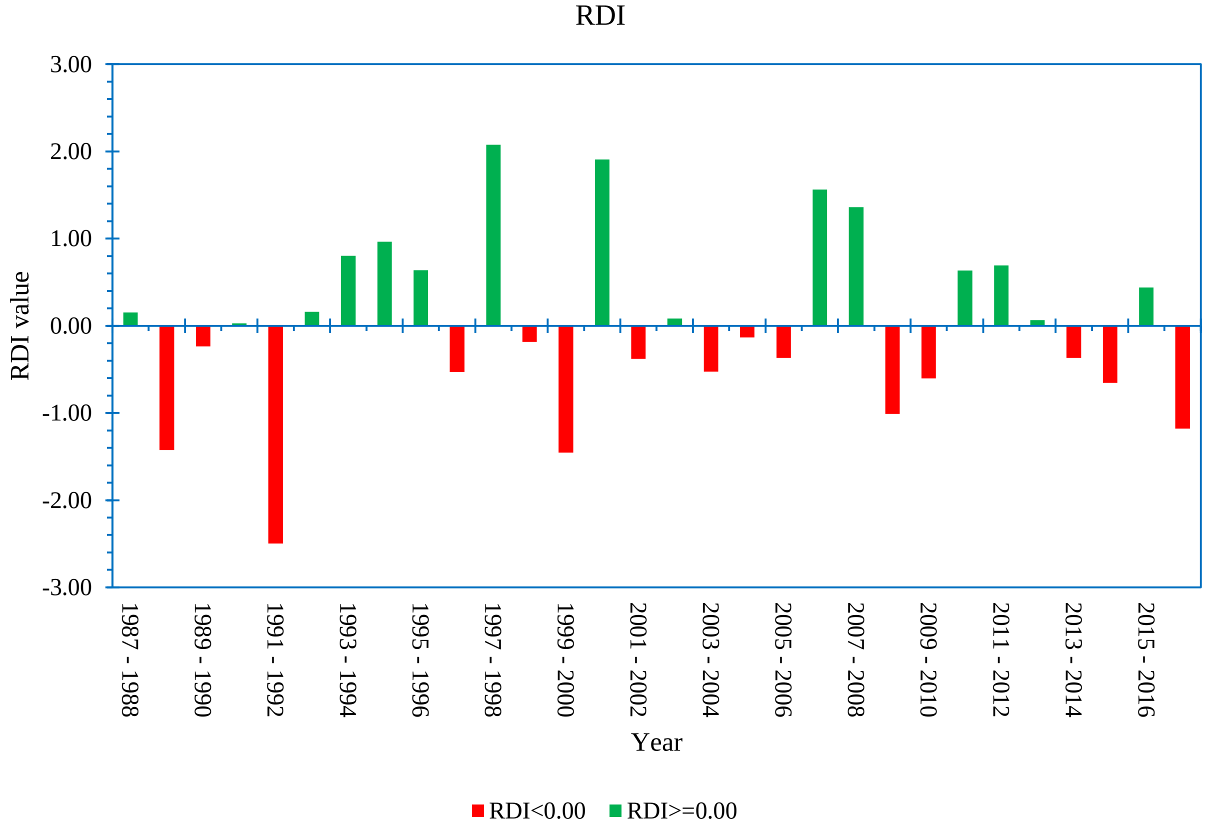


Figure 4.8 Annual Standardized Reconnaissance Index (RDIst) for Kasali sub-county from 1987 to 2017

4.1.1.5 Comparison between standard RDI and SPI values for the last 30 years (1987-2017)

From figure 4.9, the SPI and RDIst values for all the years are relatively similar. In each year the SPI and RDIst values are either positive or negative. The magnitude of the extremely dry year in both SPI (-2.50) and RDI (-2.50) is higher than the magnitude of the extremely wet year (SPI=2.03, RDI=2.07).

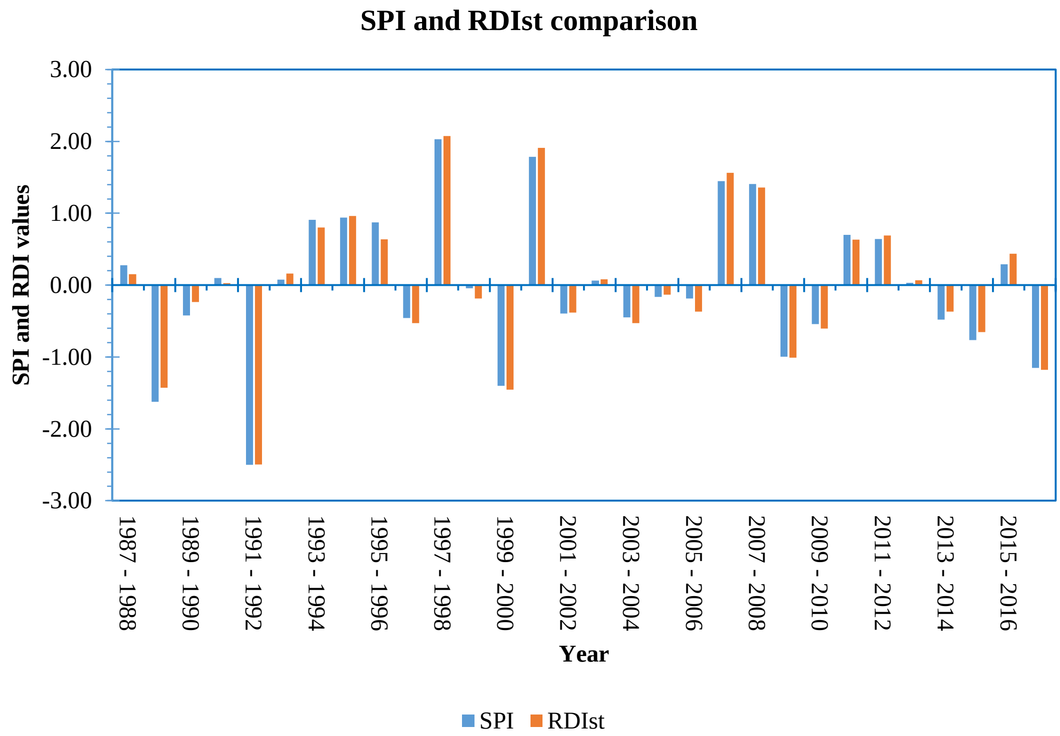


Figure 4. 9 Comparison of RDI and SPI values for Kasali sub-county from 1987 to 2017

SPI values show that one year was very wet, two years were moderately wet, three years were moderately dry and one year was severely dry. On the other hand, RDIst values show two very wet years, one moderately wet year, four years were moderately dry and no year was severely dry. Both SPI and RDIst values show that one year was extremely wet, 21 years had near normal and one year was extremely dry (figure 4.10).

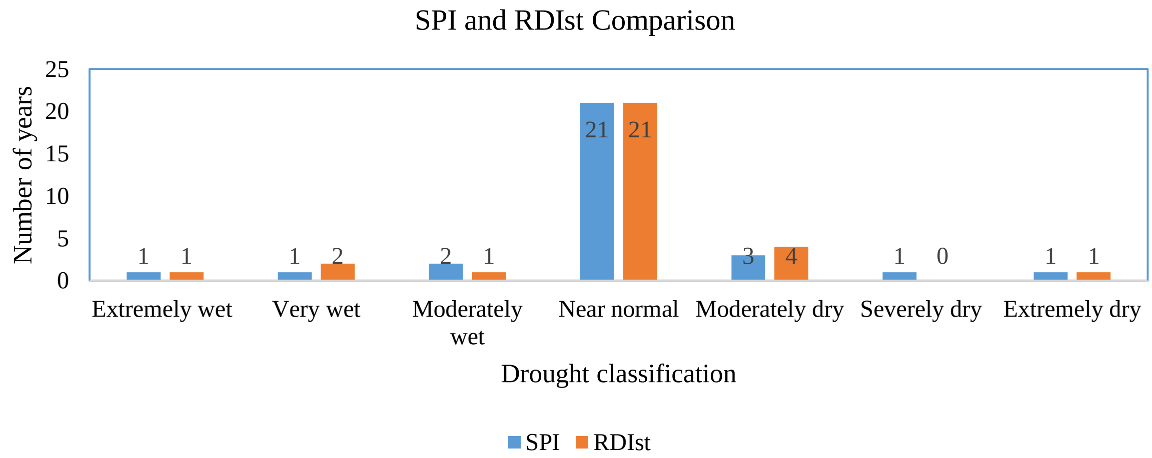


Figure 4.10 Number of years with drought classification according to SPI and RDI for Kasali sub-county

Figure 4.11, represents the number of years in percentages with drought classification for both RDIst and SPI values. Both the SPI and RDIst values of near normal had the largest percentage (70%). The SPI values show 10% moderately dry years, 4% moderately wet years, extremely dry years and severely dry years each with 3% while RDIst values show 14% and 7% for moderately dry years and very wet years respectively; the moderately wet years and extremely dry years were each 3%.

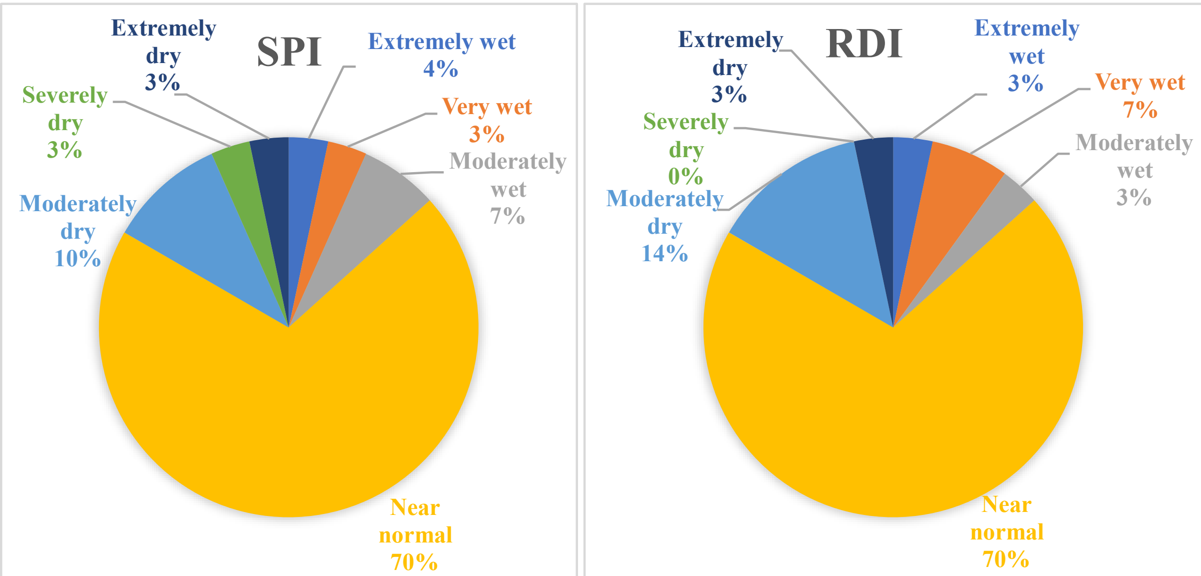


Figure 4.11 A pie chart showing the percentage of years with drought classification according to SPI and RDIst values

4.1.2 Objective two: Impact of drought on water availability in households in Kasali sub-County

4.1.2.1 Introduction

This section presents the results of the impact that drought has had on water availability in Kasali sub-county. The impact was determined through analysing the time taken by household members to collect water from the source during wet and dry years. The section also presents the water quality, source and use in Kasali sub-county.

4.1.2.2 Time spent by households collecting water during wet years.

Six villages of Kasali sub-county were undertaken for the study which included Lwengwe, Kisubi, Kyampigi, Luti, Kyango-Bigavu, and Nkenge. Time spent by households to collect water during wet years was investigated and presented in figure 4.12. Kyango-Bigavu had the largest percentage of households which spent more than one hour (32.3%) followed by Nkenge (29.0%), Lwengwe (16.1%), Kisubi, Kyampigi and Luti each had 12.9%. Kisubi had the largest percentage of households who spent one hour (22.6%) followed by Lwengwe, Kyampigi and Kyango-Bigavu each with 19.4%, Luti with 16.1% and Nkenge (0.0%). Nkenge had the largest percentage of households who spent less than one hour (74.2%) followed by Luti (71.0%), Kyampigi (67.7%), Lwengwe (64.5%) Kisubi (64.5%) and Kyango-Bigavu with 48.4% (figure 4.12).

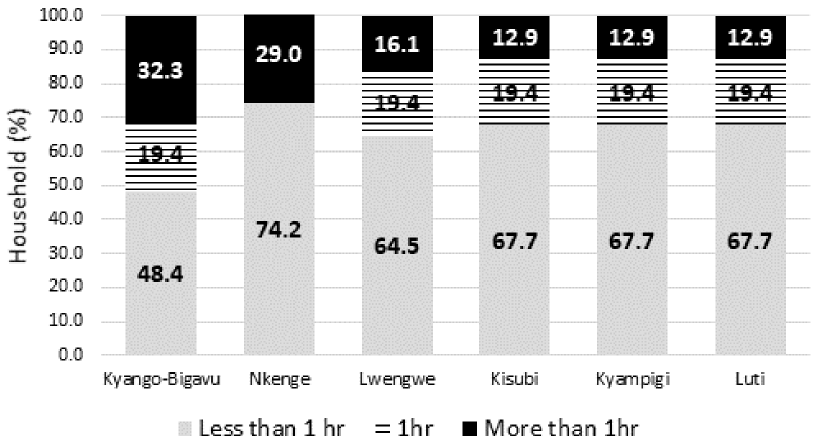


Figure 4.12 Time taken for households to collect water in wet years in the six villages of Kasali sub-county

4.1.2.3 Time spent by households collecting water during dry years.

Nkenge had the largest percentage of households which spent more than one hour (100%) followed by Kyango-Bigavu and Kisubi each with 90.3%, Luti (87.1%), Kyampigi (83.9%)

and Lwengwe with 71.0%. Lwengwe had the largest percentage of households which spent one hour (29.0%) followed by Kyampigi (16.1%), Luti (12.9%), Kisubi (9.7%), Kyango-Bigavu (6.5%) and Nkenge (0.0%). Kyango-Bigavu had the largest percentage of households that spent less than one hour (3.2%). Other villages (Nkenge, Kisubi, Luti, Kyampigi and Lwengwe) had 0.0% of the households that spent less than one hour collecting water (figure 4.13).

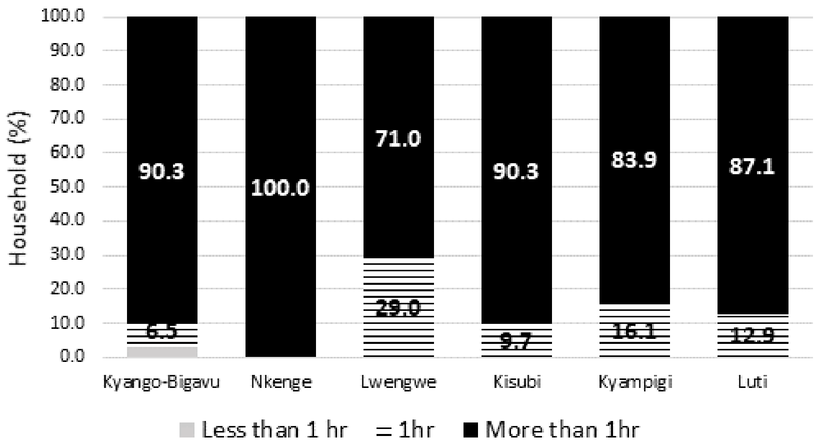


Figure 4.13 Time taken for Households to collect water in dry years in villages of Kasali sub-County

4.1.2.4 Comparison between the time taken to collect water in both dry and wet years.

85% of the households in Kasali sub-county spend more than one hour collecting water during dry years, 12% one hour and 3% less than one hour while during wet years, 65% of the households spend less than one hour, 19% more than one hour and 16% one hour. The percentage of households spending more than one hour during dry years (85%) is higher than that in wet years (19%). This means drought has a negative impact on the availability of water to the households (figure 4.14).

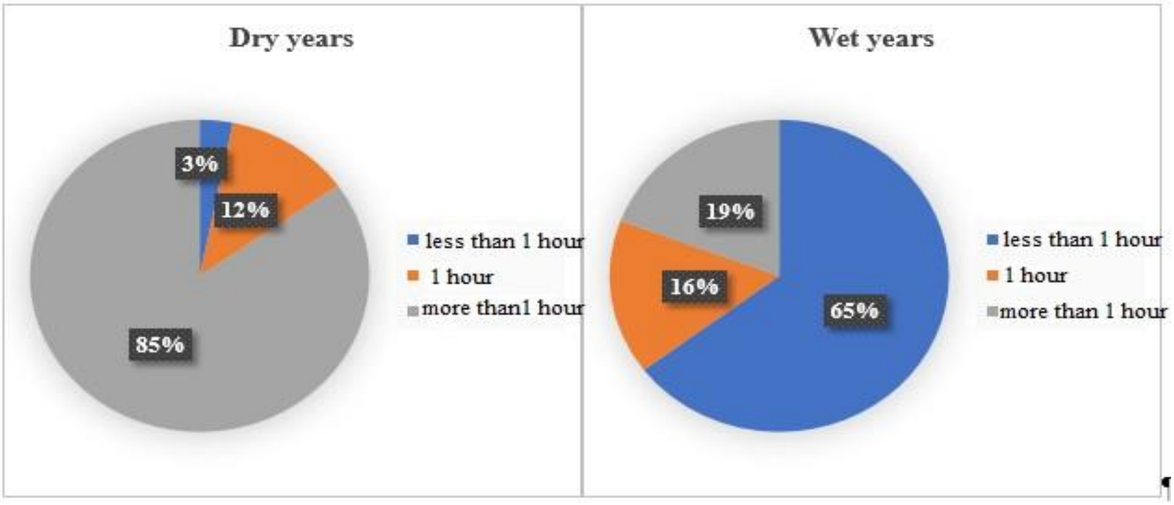


Figure 4.14 A pie chart showing the percentage of households spending less than 1hr, 1hr and more than 1hr in both dry and wet years in Kasaali sub-county.

4.1.2.5 Water quality, source and use during drought in Kasali sub-county.

Water in Kasali households is mostly for domestic use. Drinking water is specifically got from harvesting rain water however, this is only used for around one month depending on the number of members in the household since it is not enough to take them through the whole year. The rest of the months, households depend on borehole water for drinking and others depend on shallow wells. The quality of water during drought is poor and affects its use in the households. According to the respondents, the colour of the water during dry seasons changes due to increased turbidity. The colour of the water stains washed clothes and cooked food.

The sub-county has rivers with their associated wetlands and these include Katengo, Nakongongo, Kisoma and Kasemugiri. It also has 31 water points which include boreholes (14) as the major source of water, followed by shallow wells (hand dug) (13), water pumps (3) and protected spring well (1). Kigenya parish has the most number of water points (15) and Kyakonda parish has the least number of water points (2). These water sources were found to be insufficient for the households for water supply according to the respondents given the fact that some water sources like boreholes and wells dry up during drought which increases the distance that households need to cover in search for water.

4.1.3 Objective three: Adaptation strategies to water scarcity during drought by households in Kasali sub-county

4.1.3.1 Introduction

This section presents the adaptation strategies in Kasali sub-county which included, reducing the quantity of water used, migration, rainwater harvesting, piped water and buying water. The most and least adopted methods are presented together with the number of adaptation strategies adopted. The section also presents the household profiles of Kasali as collected from the questionnaires.

4.1.3.2 Household characteristics

4.1.3.2.1 Household size

Kisubi has the highest percentage of household size of 1-5 followed by Kyango-Bigavu Lwengwe, Nkenge, Kyampigi and Luti with 77.4%, 71.0%, and 61.3%, 54.8%, 54.8% and 32.3% respectively. Luti has the highest percentage of household size of 6-10 followed by Nkenge, Kyampigi, Kyango-Bigavu, Lwengwe, Kisubi with 48.4%, 45.2%, 25.8%, 22.6%, 22.6% and 12.6% respectively. Luti has the highest percentage of household size of 11-15 followed by Lwengwe, Kyampigi, Kisubi, Kyango-Bigavu and Nkenge with 19.4%, 16.1%, 16.1%, 9.7%, 6.5% and 0.0% respectively. Kyampigi is the only village with the household size of above 15 with the percentage of 3.2% (Figure 4.15). Generally, majority of household size in Kasali is between 1-5 followed by 6-10, 11-15 and above 15 with 58.6%, 29.7%, 11.3%, 0.5% respectively (Figure 4.16).

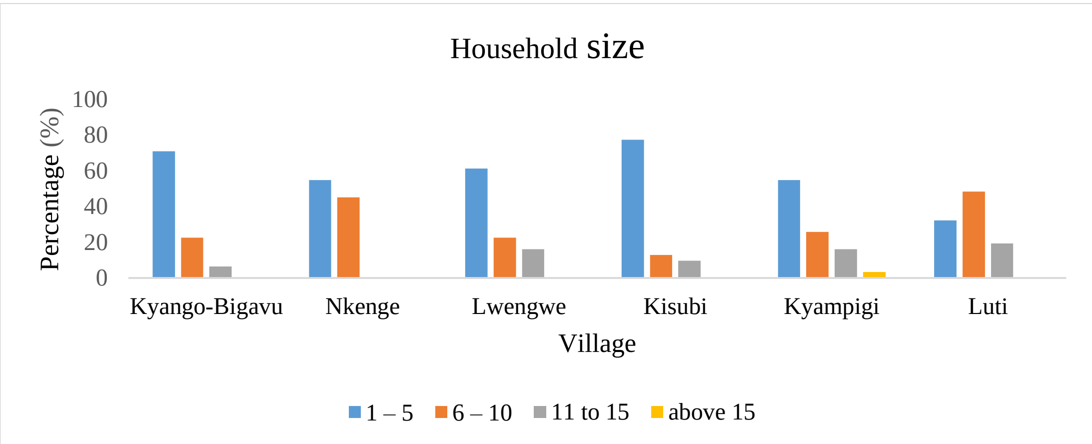


Figure 4.15 Household size for each of the selected villages

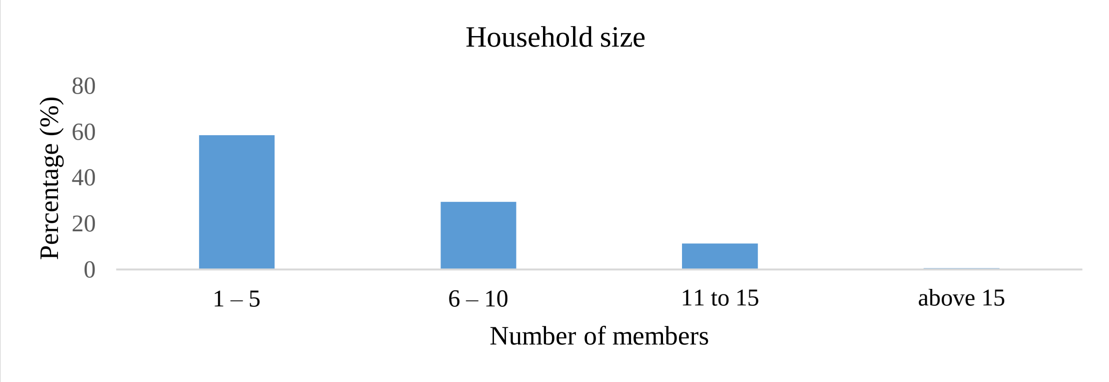


Figure 4.16 Household size of Kasali sub-County

4.1.3.2.2 Age of the household head

Kyango-Bigavu, Nkenge, Lwengwe, Kyampigi and Luti have no household head with the age group 15-25 whereas Kisubi had 3.2%. Lwengwe has the highest percentage of household heads with the age group 26-35 followed by Luti, Kyango-Bigavu, Kisubi and Kyampigi with 22.6%, 9.7%, 6.5%, 6.5%, and 6.5% respectively. Kisubi has the highest percentage of household heads with the age group 36-45 (32.3%), followed by Lwengwe (29.0%), Kyango-Bigavu (25.8%), Luti (22.6%), Nkenge (19.4%) and Kyampigi with 12.9%. Kyampigi and Luti have the highest percentage of household heads with the age group 46-55 (45.2%), followed by Nkenge (38.7%), Kisubi (32.3%), Kyango-Bigavu (19.4%) and Lwengwe with the lowest percentage of 12.9%. Kyango-Bigavu has the highest percentage of household heads with the age group 56 and above followed by Nkenge, Lwengwe, Kyampigi, Kisubi and Luti of 48.4%, 41.9%, 35.5%, 25.8% and 22.6% respectively (Figure 4.17). Generally, majority of household heads in Kasali fall in the age group of 56 years and above followed by those in 46-55 years (32.2%), 36- 45 (23.7%), 26-35 (8.6%) and the lowest being 15-25 (0.5%) (Figure 4.18).

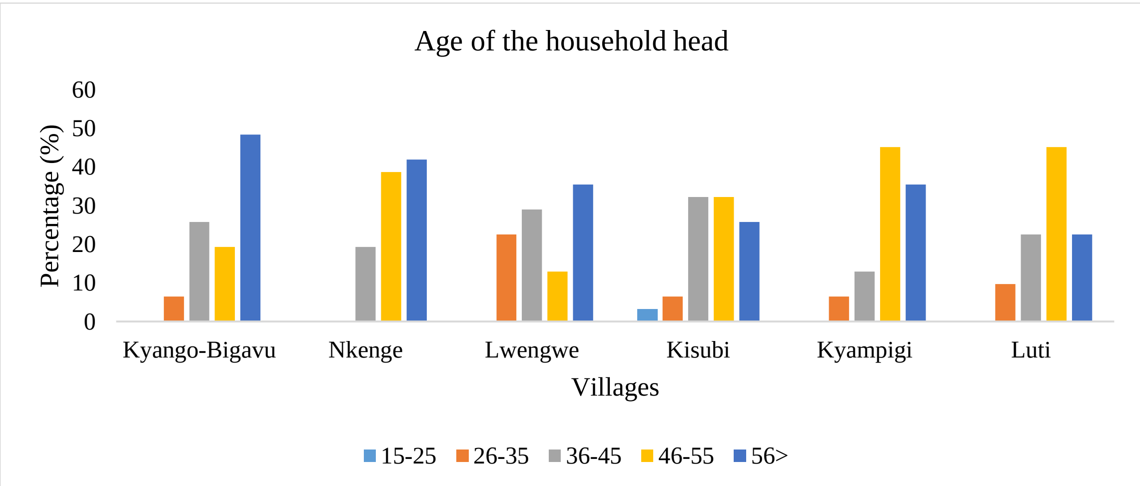


Figure 4.17 Age of household heads in each of the selected villages

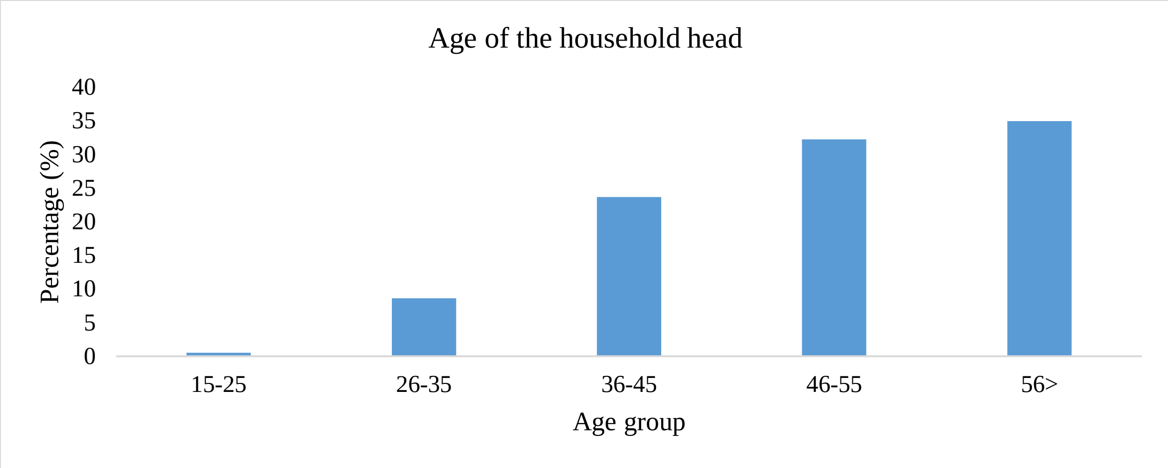


Figure 4.18 Age of the household heads in Kasali sub-county

4.1.3.2.3 Level of education of household heads

Kyampigi has the highest percentage of household heads who never attended school with a percentage of 58.1% followed by Nkenge (54.8%), Kisubi (51.6%), Lwengwe (48.4%), Kyango-Bigavu (25.8%) and Luti with 19.4%. None of the household head attended preschool. Luti has the largest percentage of household heads who attended primary followed by Kyango-Bigavu, Lwengwe, Nkenge, Kisubi and Kyampigi with 74.2%, 67.7%, 45.2, 41.9%, 41.9% and 38.7% respectively. Kyango-Bigavu, Lwengwe, Kisubi and Luti each had a percentage of 6.5% of the household heads who attended secondary, Nkenge had 3.2% while Kyampigi had no household head who attended secondary level. Only Luti had a percentage of 3.2% of the households who attended higher education (Figure 4.19). Generally, majority of household heads in Kasali attended primary with the percentage of 51.6% followed by those who never attended school (43.0%), senior school (4.8%) and the least being higher education with 0.5% (Figure 4.20).

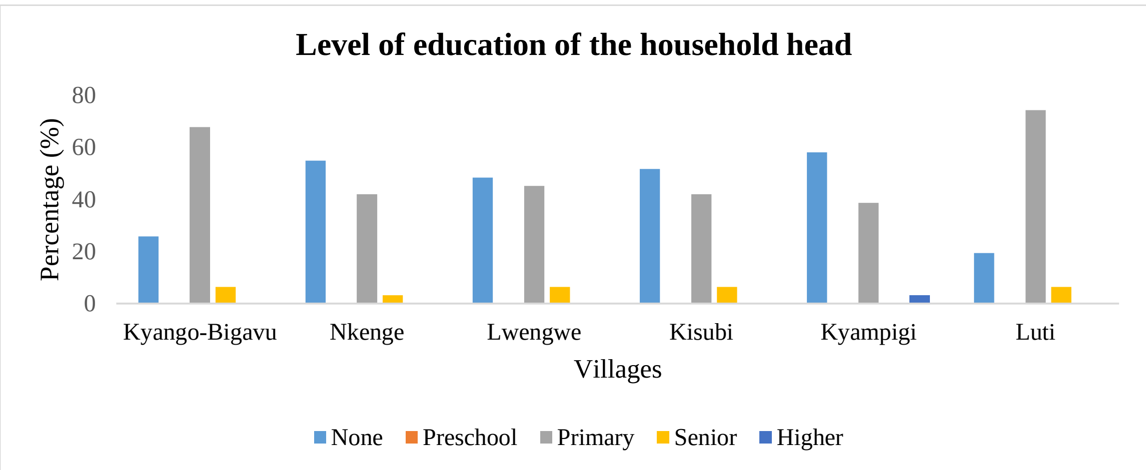


Figure 4.19 Level of education of household heads

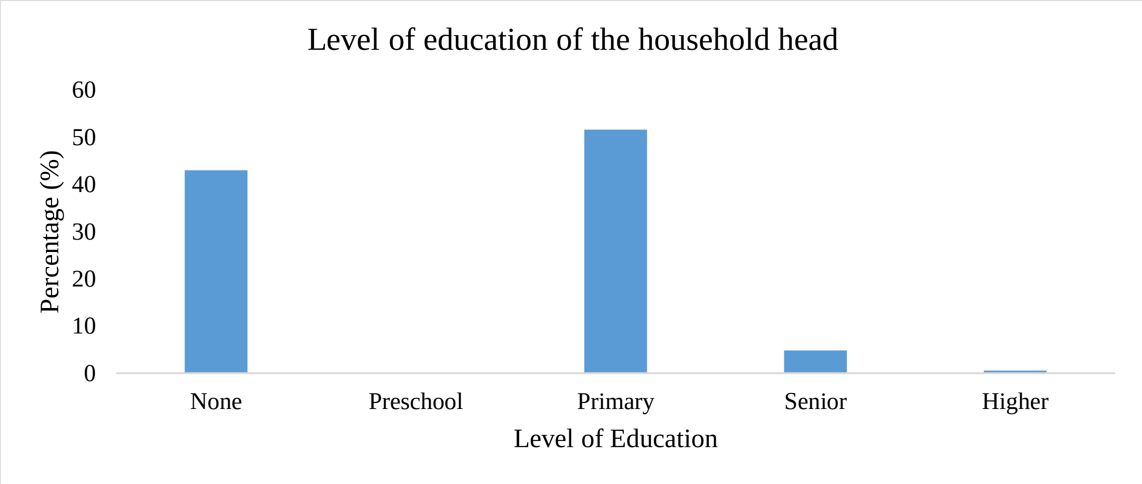


Figure 4.20 Level of education of household heads in Kasali sub-county

4.1.3.2.4 Marital status of Household heads

From the figure 4.23, it can be revealed that most household heads are married. Kyampigi has 77.4%, Kisubi, Nkenge and Luti each with 74.2%, Lwengwe with 64.5% and Kyango-Bigavu with 58.1%. Kyango-Bigavu and Lwengwe each had 22.6% of widowed households followed by Luti with 19.4%, Nkenge with 16.1%, Kyampigi with 12.9% and Kisubi with 9.7%.

Kyango-Bigavu has 19.4% separated household heads, Lwengwe has 12.9%, Nkenge and Kyampigi each with 9.7% and Kisubi and Luti each with 6.5% (Figure 4.21). Generally, Kasali sub-county had married household heads as the majority with a percentage of 70.4% followed by widowed (17.2%), separated (1.8%) and the least were the single headed households with 1.6% (Figure 4.22).

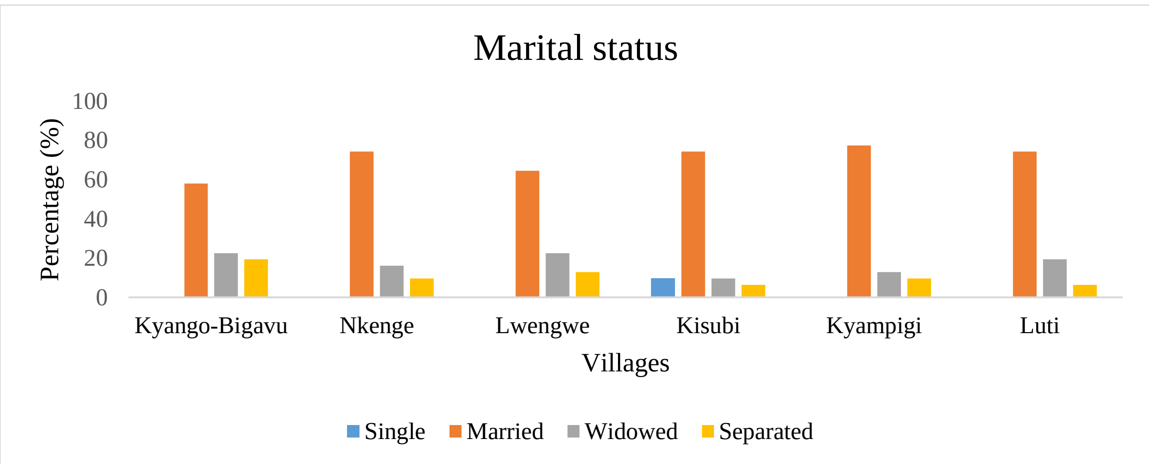


Figure 4.21 Marital status of household heads

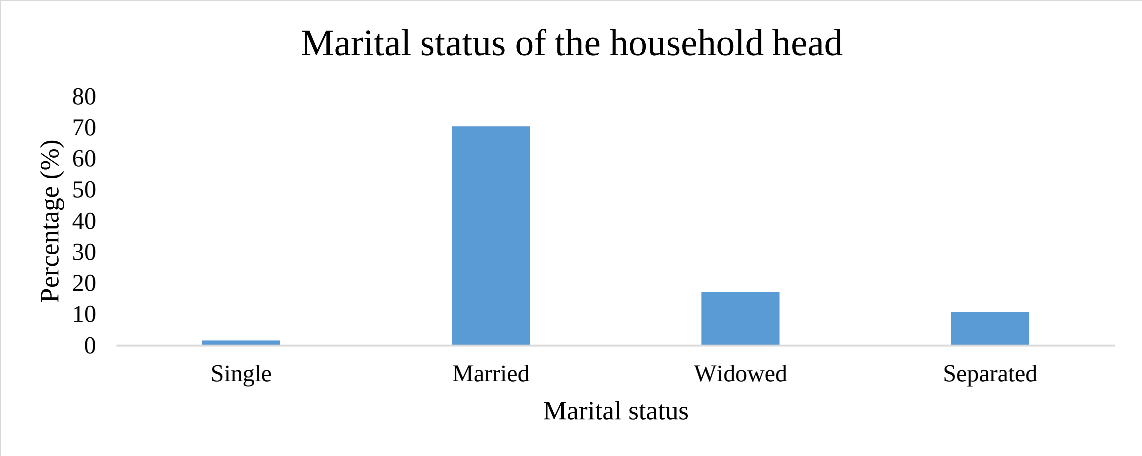


Figure 4.22 Marital status of household heads in Kasali sub-county

4.1.3.2.5 Gender of the Household head

The majority of the households are headed by male with Kyampigi having the largest percentage of male household heads followed by Lwengwe, Kisubi, Luti, Kyango-Bigavu and Nkenge with 87.1%, 80.6%, 80.6%, 80.6%, 74.2% and 67.8%. respectively. Nkenge has the highest percentage of households headed by a female followed by Kyango-Bigavu, Lwengwe, Kisubi, Luti and Kyampigi with 32.3%, 25.8%, 19.4%, 19.4%, 19.4% and 12.9% respectively (Figure 4.23). Generally, households in Kasali are headed by males with the percentage of 78.5% whereas females are 21.5% (Figure 4.24).

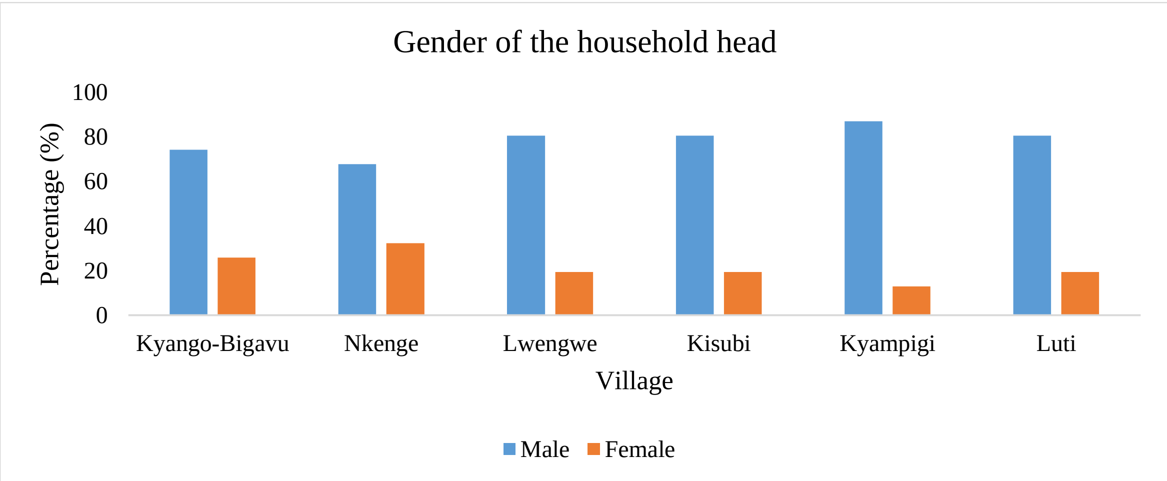


Figure 4.23 Gender of household heads in each of the selected villages

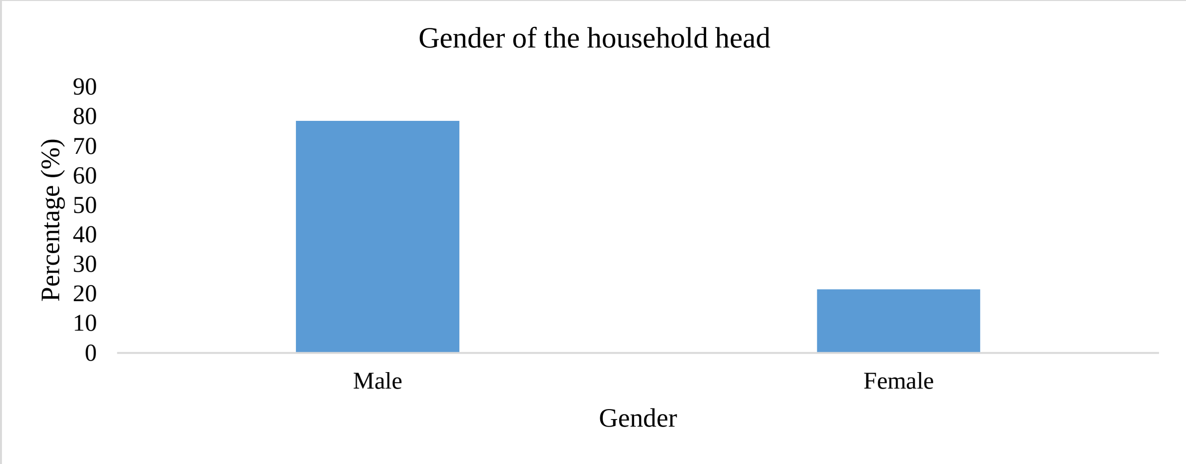


Figure 4.24 Gender of household heads in Kasali sub-county

4.1.3.3 Adaptation Strategies in Kasali sub-county

The study analysed the five adaptation strategies of households in Kasali sub-county which include reducing quantity of water used during drought, harvesting water, piped water, migration and buying water. Results show that the major adaptation strategy is reducing the quantity of water used during drought followed by harvesting water, piped water, buy water and migration in search for water with 42.7%, 39.9%, 11.0%, 6.4% and 0.0% respectively (Figure 4.25).

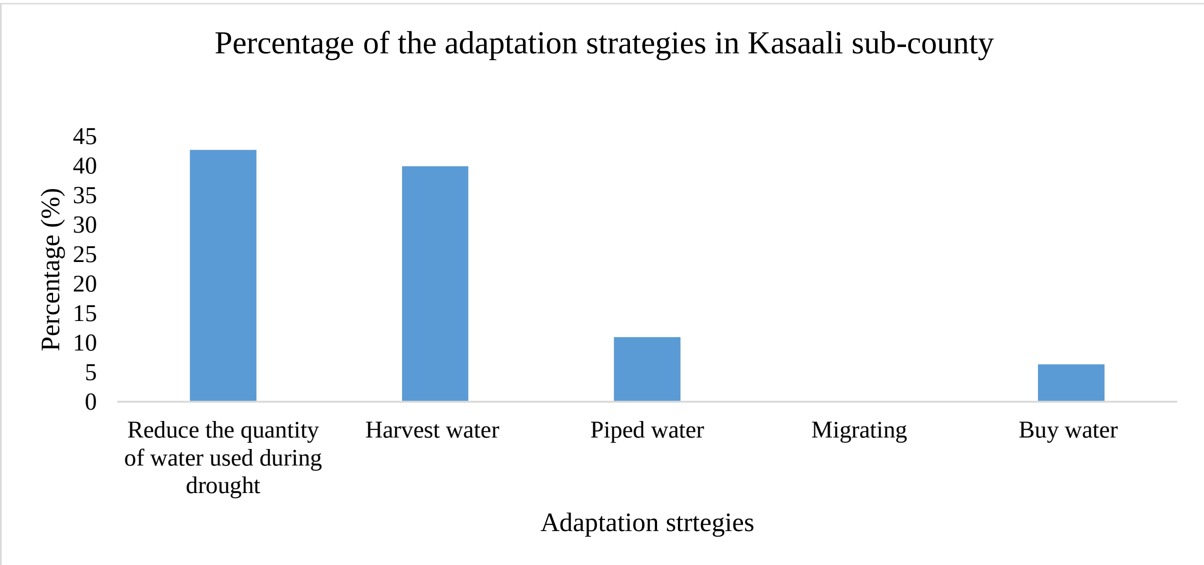


Figure 4.25 Percentage of adaption strategies among households in Kasali sub-county

The results (Figure 4.26**)**, reveal that 43.5% of the households in Kyango-Bigavu reduce quantity of water used during drought, 48.4% harvest water and 8.1% buy water. No households migrate in search for water and use piped water. In Nkenge, 19.5% of the households reduce quantity of water used, 48.9% harvest water, 18.8% use piped water, 18.8% buy water and no households migrates in search for water. Lwengwe village has 48.7% of the households who reduce the quantity of water used during drought, 32.1% harvest water, 10.3% use piped water, 5.1% buy water and no household migrates in search for water. In Kisubi, 53.5% reduce quantity of water used, 30.2% harvest water, 10.0% use piped water and no household migrates in search for water. Kyampigi has 42.1% of the households who reduce quantity of water used, 39.5% harvest water, 13.2% use piped water, 5.3% buy water and no household migrates in search for water. In Luti village 48.9% of the households reduce quantity of water used, 42.6% harvest water, 6.4% use piped water, 2.1% buy water and no household migrates in search for water (Figure 4.26).

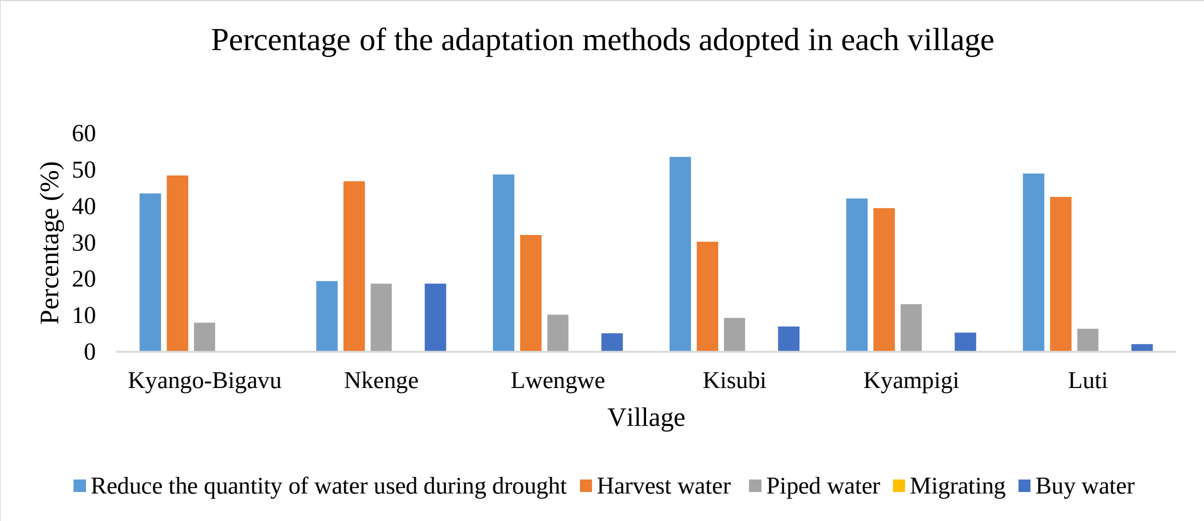


Figure 4.26 Adaptation strategies used by different households in the six selected villages in Kasali sub-county

Majority of the households in Kasali sub-county practice only two adaptation strategies (48.1%) followed by those practicing only one adaptation strategies (33.4%) and fewer practice more than two adaptation strategies (19.7%) (Figure 4.27).

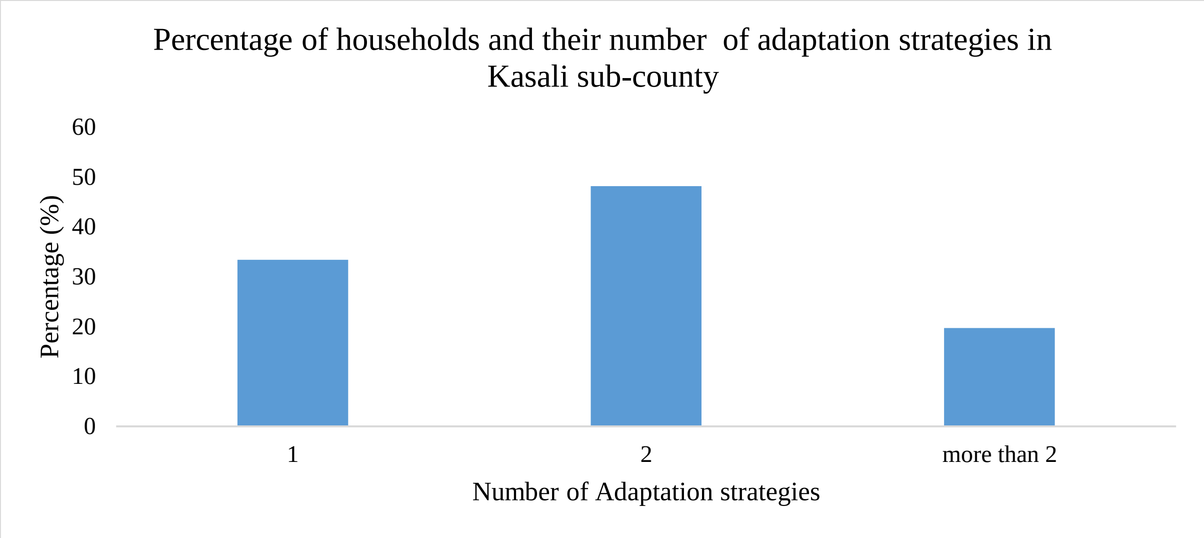


Figure 4.27 Percentage of the households and their number of adaptation strategies

The percentage of households practicing only one adaptation strategy are 30.8%, 39.7%, 31.4%, 33.1%, 15.4% and 50% in Kyango-Bigavu, Nkenge, Lwengwe, Kisubi, Kyampigi and Luti respectively. Practicing two adaptation strategies is more popular with households ranging between 48.5%, 40.5%, 54.3%, 53.8%, 65.4%, and 26.3% in Kyango-Bigavu, Nkenge, Lwengwe, Kisubi, Kyampigi and Luti respectively (Figure 4.28).

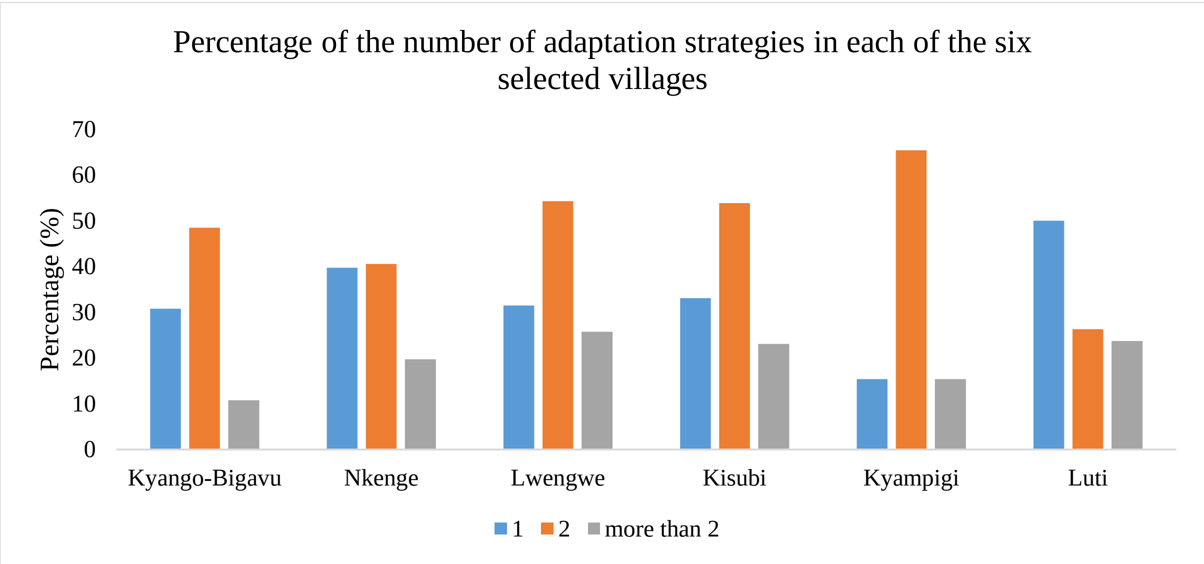


Figure 4.28 Number of adaptation strategies in each the selected villages of Kasali sub-county

4.1.4 Objective four: Assess the indicators of adaptive capacity of households to water scarcity during drought in Kasali sub-county

4.1.4.1 Introduction

This section presents the results from the assessment of the five indicators of adaptive capacity which include; financial and economic resource (FE), infrastructure and institutions (II), technology and innovation (TI), knowledge and information (KI) and social resource (SR). It also presents the ranking of the adaptive capacity of the six selected villages (Luti, Lwengwe, Nkenge, Kisubi, Kyampigi and Kyango-Bigavu) and the general Kasali sub-county based on the above indicators.

4.1.4.2 Indicators of adaptive capacity in the villages of Kasali sub-county

The indicators of adaptive capacity investigated were infrastructure and institutional resources, knowledge and information resources, social resources, financial and economic resources, technology and innovation resources and the results are presented in table 4.7.

Table 4.7 Mean scores of indicators of adaptive capacity in each of the six selected villages of Kasali Sub-county

Indicators of Adaptive Capacity	Kyango-Bigavu	Nkenge	Lwengwe	Kisubi	Kyampigi	Luti	Mean score
Infrastructure and institutions resources	2.57	2.23	1.97	1.87	1.57	1.67	1.98
Technology and innovation resources	1.56	2.45	1.56	1.56	1.35	1.01	1.58
Social resources	3.45	3.25	3.23	2.45	3.63	2.47	3.08
Financial and economic resource	2.34	1.98	1.43	1.43	1.97	1.02	1.70
Knowledge and information resources	3.35	3.23	1.23	1.45	1.99	1.01	2.04
Mean score	2.65	2.63	1.88	1.75	2.10	1.44	2.08

Table 4.8 Classification of the adaptive capacity of the households.

Mean Score	Level of Adaptive Capacity
0.00 – 2.49	Low adaptive capacity
2.50 – 3.49	Moderate adaptive capacity
3.50 – 5.00	High adaptive capacity

Source: Abaje *et al*, 2015

From the results (Figure 4.29), infrastructure and institution as an indicator of adaptive capacity in Kyango-Bigavu is moderate (2.57). In Nkenge, Lwengwe, Kisubi, Luti and Kyampigi, infrastructure and institution resource is low with mean scores of 2.23, 1.97, 1.87 and 1.67 respectively. Knowledge and information resources as an indicator of adaptive capacity is moderate in Kyango-Bigavu and low in Lwengwe, Kisubi, Kyampigi and Luti with mean scores of 3.53, 1.23, 1.45, 1.99 and 1.01 respectively. Social resource as an indicator is high in Kyampigi, moderate in Kyango-Bigavu, Nkenge and Lwengwe, low in Luti and Kisubi with mean scores of 3.63, 3.45, 3.25, 3.23, 2.47 and 2.45 respectively. Financial and economic resources as an indicator of adaptive capacity in Kyango-Bigavu, Nkenge, Kyampigi, Lwengwe, Kisubi and Luti is low with mean scores of 2.34, 1.98, 1.97, 1.43, 1.43 and 1.02 respectively. Technology and innovation resource is low in Nkenge, Kyango-Bigavu, Lwengwe, Kisubi, Kyampigi and Luti with a mean score of 2.45, 1.56, 1.56, 1.56, 1.35 and 1.01 respectively.

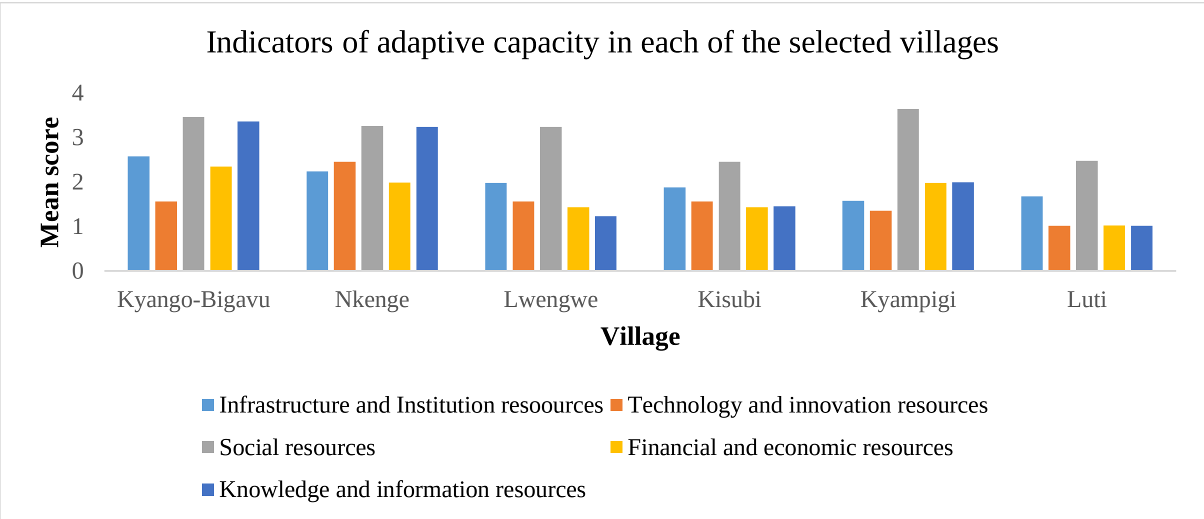


Figure 4.29 Indicators of adaptive capacity in each of the selected villages

Figure 4.30 shows the overall mean scores of each indicator of adaptive capacity in Kasali sub-county. Results show that social resource is high (3.08), knowledge and information resource, infrastructure and institutional resources, financial and economic resources and technology and innovation resource are low with mean scores of 2.04, 1.98, 1.70 and 1.58 respectively.

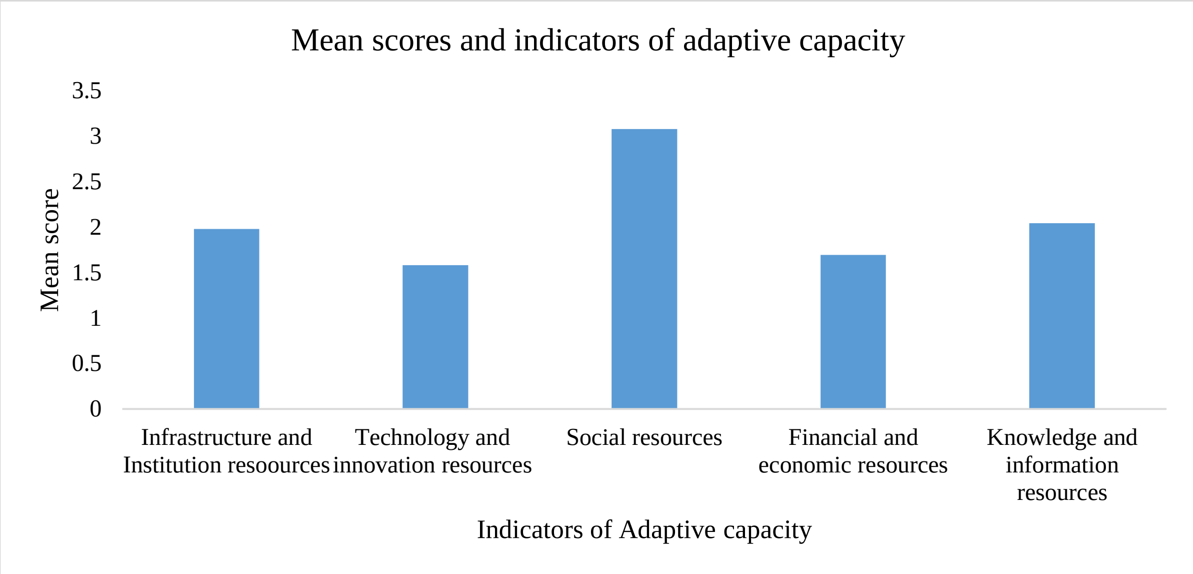


Figure 4.30 Mean scores of the indicators of Adaptive capacity in Kasali sub-county.

The overall mean score of the indicators of adaptive capacity in each village show that Kyango-Bigavu and Nkenge has a moderate adaptive capacity with mean scores of 2.65 and 2.63 respectively. The rest of the villages Kyampigi, Lwengwe, Kisubi and Luti village with mean scores of 2.10, 1.88, 1.75 and 1.44 respectively have a low adaptive capacity. (Figure 4.31).

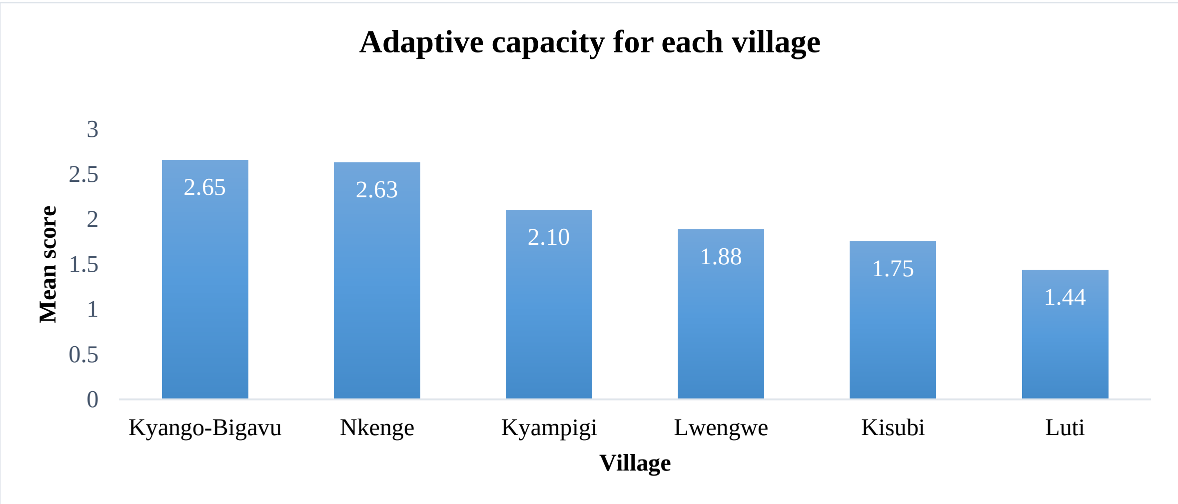


Figure 4.31 The mean score of the adaptive capacity to water scarcity for each of the selected villages in Kasali sub-county.

4.2 DISCUSSION

4.2.1 Temperature and rainfall trends in Kasali sub-county

Indices for drought classification are determined from climate parameters (temperature and rainfall). The results show that the region has two rain seasons one starting from March to May (MAM) and another starting from September to December (SOND). Further analysis indicates that there was a reduction in the average rains of MAM (tau=-0.030, p=0.8251), annual (tau=-0.024, p=0.8650) which were not statistically significant and JF (tau=-0.135, p=0.2919) which was statistically significant. There was a slight increase in JJA (tau=0.079, p=0.5406) and SOND (tau=0.105, p=0.4146) rains which were statistically significant at p>0.5. This result is consistent with studies in the neighboring district of Rakai which has the same ecological zone with Kasali by Mubiru *et al*. (2015). The IPCC fifth edition also observed that the rainfall amounts in East Africa had reduced for the past 50-100 years (IPCC, 2014). The general decline in the rainfall amount from 1987 to 2017 can be attributed to the physical systems like El Niño Southern Oscillation and rapid warming of the Indian Ocean (IPCC, 2014).

The results also show that the annual maximum and minimum temperature has increased by 0.7°C and 1.2°C respectively in the period of 30 years. This result is consistent with the IPCC fifth assessment report which revealed that the surface temperature of East Africa has already increased by 0.5-2.0°C in the last 50-100 years (Ghebrezgabher *et al*, 2016; IPCC, 2014).

4.2.2 Drought frequency and intensity in Kasali sub-county

Temperature and rainfall in Kasali were used to calculate SPI and RDI values for drought analysis. The SPI values were achieved by standardizing rainfall in Kasali. During the study period (1987-2017), Kasali experienced all the categories of drought (extreme, severe, moderately and near normal) (Table 4.6). Standardized RDI values show three drought categories; near normal, moderately dry and extremely dry. The driest year was 1991-1992 for both SPI and RDI. Severe and extreme drought normally occur during La Nina periods. These periods are brought about by a decrease in the sea surface temperature in the eastern side of the Pacific Ocean which is associated with dry conditions in East Africa (Ghebrezgabher *et al*., 2016; Shilenje *et al*, 2019). The year 1999-2000 was moderately dry year. This observation is consistent with the drought observed in the Horn of Africa in years 1999-2000, 1991–1992 2010–2011, 2016-17 (Brietzke and Caputo, 2019; Masih *et al*., 2014). SPI and RDI values show approximately similar results and this makes them appropriate in drought analysis, however, RDI indicates more dry years with higher intensities than SPI. This is because RDI accounts for more climate parameters like potential evapotranspiration which makes RDI more sensitive in analyzing drought than SPI. This is in consistent with studies by Shokoohi and Morovati (2015), who stated that SPI and RDI values in drought analysis matches in many ways with less differences.

4.2.3 Impact of drought on water availability to the households in Kasali sub-county

The research studied drought impact on water availability in Kasali through determining and comparing the time households spend in collecting water during dry and wet years. The results show that majority of households spend longer hours collecting water in dry years than in wet years. This is because household members move for longer distances in search of water during dry years and a number of households have unsustainable means of storing water for future use which leads to water scarcity as revealed by respondents. These findings are in consistent with a study in Kaliro district in eastern Uganda which found out that household members especially women struggle in accessing water during drought as a result of drying up of the nearby water sources like wells and river beds and they have to walk miles in search for water (LWR, 2017). The study also reveals that there are few water points in the region (31). The major water points are boreholes (15) and shallow wells (13). Some parishes like Kigenya have 2 water points (all boreholes) and Gayaza has 3 water points (2 boreholes and 1 shallow well) (Figure 4.16). These sources however are vulnerable to drought for example the shallow wells dry up during drought and boreholes become defunct due to over usage; the water pressure from the boreholes also reduces according to the respondents and this could be due to a decrease in the water table during drought. This also contributes to the length of time households spend while collecting water during drought. The less time spent during wet years, means that households easily acquire water nearby their home. Households also harvest water during wet years. Furthermore, the rains fill up nearby seasonal ponds and wells hence they have easy access to these sources of water during wet years. This correlates with findings from Ethiopia which stated that households always have easy access to water during wet years (Dessalegn *et al*, 2013).

These results imply that drought has a negative impact on water availability to the households in Kasali sub-county. These results are also in conformity with the findings of WFP which stated that drought has a negative impact on water resources by reducing the amount of water in the water sources which in turn increases the time households spend while collecting water (Aben *et al*., 2012).

The quality of water during drought in Kasali is also poor and this affects the water use by the households. The increased use of the few available water sources, increases water turbidity hence contaminating it and changing its natural colour. This is in consistence with studies in the region which revealed that the colour of water during dry seasons changes and leads to staining of washed clothes and cooked food (Ademun, 2009).

4.2.4 Adaptation strategies to water scarcity in Kasali sub-county.

As a result of the negative impact that drought has had on water availability leading to water scarcity, households have adopted adaptation strategies. The study investigated five adaptation strategies which include reducing quantity of water used during drought, harvesting water, piped water, migration in search for water and buying water. Reducing the quantity of water used is the most practiced adaptation method. This is an ex-post strategy used to reduce shortfalls in consumption especially when there is a drop in income generation as a result of a climate shock (FAO, 2014). Households are then forced to reduce water expenditure on non-essential activities resorting to public relief and safety net programs (Pandey *et al*, 2007). This study is in consistence with findings in Nepal which revealed that majority of rural households adopt low cost and capital investment adaptation strategies like reduction in consumption of the amount of water during drought (Shankar, 2018). In Shinile and Konso (Ethiopia), households adopt adaptation strategies in response to water scarcity like reducing water consumption for bathing and washing clothes (Dessalegn *et al*., 2013).

The second most adopted adaptation strategy is rain water harvesting. Rain water harvesting is a great asset to tackle the problem of water scarcity because it enables households to collect and store water that can be used later in the year especially during drought (Shankar, 2018). Most parts in the world answer the problem of water scarcity through water harvesting since its easily available (Salerno, 2017). This explains why this method is one of the mostly adopted adaptation strategy in Kasali sub-county.

The percentage of households who buy water (6.4%) and use piped water (11.0%) as adaptation strategies is smaller than the percentage of households which reduce the quantity of water used during drought (42.7%) and that for water harvesting (39.9%). Structural measures to adapt to water scarcity during drought like piped water system, require higher capital investment (Shankar, 2018) that many households in Kasali may find difficult to afford unless they have support from the government. According to UBOS (2017), the percentage of Ugandan households living below the poverty line is 27%. This is a big percentage that encompasses mostly the rural areas like Kasali. With such poverty levels, adaptation strategies that require high costs like piped water and buying water are less adopted than those that require low or no capital.

There is no household which migrates in search of water. Rain failures prompt households to migrate. The migration may either be temporary or permanent depending on the intensity and length of the rain failures (Dessalegn *et al*., 2013). This strategy (migration) is highly common among pastoral communities for example the Karamajong of Uganda, Turkana of Kenya and some communities in Ethiopia (Carabine *et al*, 2017; Dessalegn *et al*., 2013). Such an adaptation strategy is not adopted in Kasali because it is a non-pastoral community.

The findings also reveal that few households practiced more than two adaptation strategies. This could be due to limited access to climate information for them to prepare prior to drought, limited access to credits and extension information (Maguza-Tembo *et al*, 2017). These findings are consistent with studies by Teklewold *et al* (2019) which revealed that few households adopt multiple strategies of adaptation in the Nile basin of Ethiopia because of limited resources.

4.2.5 Adaptive capacity to water scarcity in Kasali sub-county

The adaptive capacity of households to water scarcity during drought was investigated based on the five major indicators of adaptive capacity which include social capital, knowledge and information resource, infrastructure and institution resource, financial and economic resource and technology and innovation resource.

Results indicate that social resource in Kasali is high (3.08). Social network establishes better communication and collective actions especially during times of stress (Adger, 2003). In addition, it allows people to come together for a common goal. In case of challenges like water scarcity during drought, people easily come together to help each other through innovative projects like water harvesting mechanisms, fundraising for construction of communal water points like boreholes, communal rehabilitation and reconstruction of water wells in order to have continued and constant supply of water in the villages (Gbetibouo, 2009). Kasali having a social resource score of 3.08 (high adaptive capacity) means that it is easy for its households to collectively come together in order to adapt to water scarcity during drought.

Knowledge and information resource is low (2.04). The assumption is that higher levels of knowledge and information resource increase adaptive capacity by boosting the capacity of people's to access information (Gbetibouo, 2009; Thornton *et al*, 2006). Lower knowledge and information capacity affects the ability to access and understand early warning information (Cutter *et al*., 2003). Based on this assumption, Kasali with a low knowledge and information resource has a low adaptive capacity to water scarcity during drought.

Infrastructure and institutional resources are low (1.98). Institutional resources are important for the use of adaptation methods in rural areas (Deressa *et al*., 2010). Good roads allow easy transportation of water to the remotest households. They also influence the effectiveness of water distribution programs during drought (Gbetibouo, 2009). Communities having well developed infrastructure and institutions adapt better to drought than those with less developed infrastructure and institutions (Adger *et al*., 2005; Brien *et al*., 2004). This means that water access to households in Kasali is hard because they have a low infrastructure and institution resource hence low adaptive capacity to water scarcity during drought.

The financial and economic resources were low (1.70). Availability and access to financial and economic resources and income stability helps in boosting households' adaptive capacity to water scarcity (Armitage, 2005; Yohe and Tol, 2002). Kasali has experienced drought seasons which have affected their livelihood (agriculture) (Mubiru *et al*., 2015). This has affected their income generation. These findings are in line with MoALF (2016) which found that majority of residents in Kasali sub-county had a low income. Low income limits memberships to social groups to act as security for credits and loans and diversification of economy for better income (Abaje *et al*, 2016). Kasali having a low financial and economic resource means that they can't afford better and sustainable adaptation strategies to water scarcity during drought.

Technology and innovation resource was low (1.58). According to Sorre *et al*. (2017) a key feature of adaptive capacity is the ability of the system to build innovation and support new practices. Access to new technologies and their integration into the available practices, aids adaptive capacity (Yohe and Tol, 2002). The introduction of new technologies depends on how much new practices differ from the available methods and how they are well matched with the existing systems (Lybbert and Sumner, 2012). Kasali has a low technology and innovation resource and therefore its adaptive capacity to water scarcity during drought is low. The overall score of the indicators of adaptive capacity show that Kasali has a low adaptive capacity to water scarcity during drought. This can further be attributed to the household characteristics in the region for example household size. 58.6% of the households in Kasali had 1-5 household size compared to 6-10 (29.6%), 11-15 (11.3%) and above 15 (0.5%). Household size is considered to influence the adaptive capacity of the household (Shirima, 2017). This is partly due to the available household labor which is based on household members for production (Shirima, 2017). Other studies like one by (Kayunze, 2011), showed that household size is an important asset in relation to working together to improve the economy of the household. Therefore, the small household size (1-5) in Kasali could have contributed to the households' low adaptive capacity to water scarcity during drought.

Household age determines the adaptive capacity of households because it influences the number and type of adaptation strategies adopted by a given household (Tembo, 2013; Yesuf, 2008). Villages with low adaptive capacity like Luti, Kyampigi and Nkenge are characterized by age of household head of 46-55 and above 56. The study therefore reveals that heads of household with 46 and above years are associated with low adaptive capacity. According to Shirima (2017), advances in age has a negative impact on adaptive capacity because it reduces and limits the chances of accessing resources at the same time limiting the household head from accessing alternative livelihood sources to sustain the economy of the livelihood. When household heads become aged, they instead become dependents and only decision makers on the property which they own (Shirima, 2017). This implies that, increase in the age of household's head will subsequently lead to low adaptive capacity of the entire household Households in Kasali sub-county had a small percentage of households between 26-35 years (8.6%). This could explain the low adaptive capacity in the region since this age group is known to be energetic and hardworking to improve households' adaptive capacity.

According to Davidson and Lees (2010), education level has a central role in promoting understanding and helping individuals and communities make informed choices to tackle problems of climate change. Kasali is associated with majority of household heads who attended primary (51.6%) and a relatively bigger percentage (43.0%) who never went to school. This could also explain why households in Kasali adopt majorly one (33.4%) and only two (48.1%) adaptation strategies to water scarcity. Higher education levels (senior and above) is appropriate for proper acquisition of skills and knowledge about better adaptation strategies to water scarcity because it is associated with villages that have moderate and high adaptive capacity to water scarcity during drought. Ellis (2000) also indicates that human resources are related to the quality of work and skills. High human resources, like more education and longer experience, provides knowledge and skills to adapt to the effects of climate change, resulting in greater adaptive capacity. This affects the type and number of adaptation strategies adopted because Kasali with majorly one and only two adaptation strategies to water scarcity being adopted, is characterized by a larger percentage of household heads who never attended school (43.0%) and those who attended primary (51.6%).

It should be noted that adaptive capacity determinants depend on each other (Smit and Wandel, 2006). Forexample, financial and economic resource availability increases households' adaptive capacity through improving their infrastructure and institutions, plus other resources used in water scarcity adaptation during drought.

5.0 CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

It is evident that Kasali has experienced five dry years ranging from moderately dry to extremely dry in the last 30 years (1987-2017). There was one extremely dry year and four moderately dry years based on RDI while SPI values showed one extremely dry year, one severely dry year and three moderately dry years.

The minimum temperature increased much more than the maximum temperature from 1987 to 2017. The Minimum and maximum temperature increased at a rate of 0.4ºC and 0.2ºC per decade respectively. This means that minimum temperature has increased more than the maximum temperature. Rainfall has also decreased over the period and this has contributed to water scarcity.

Majority of households in Kasali spend longer time while collecting water in dry years than in wet years. This means that drought has caused a negative impact on water availability in this region.

Kyango-Bigavu and Nkenge have a moderate adaptive capacity where are Lwengwe, Kisubi, Kyampigi and Luti has a low adaptive capacity. Kasali generally has a low adaptive capacity.

5.2 Recommendations

The study recommends that development efforts should focus on sensitizing households on drought impact on water availability, provision of early warning systems and livelihood diversification to improve their income. More water points should be provided to the sub-county since there are few. Better water policies that will improve the adaptive capacity of the villages in Kasali should be put in place. The policies should restructure responsibilities, roles and strategies for adaptation to water scarcity, through stakeholder involvement. Indicators of adaptive capacity have to be improved especially financial and economic and technology and innovation starting with villages that have low adaptive capacity like Luti. This should be done through provision of alternative adaptation strategies that are self-sustaining. The study also recommends further studies on drought monitoring and coming up with long term predictions of climate parameters, drought occurrence, intensity and frequency. This will enable households and other stakeholders to come up with long term adaptation and mitigation strategies to reduce on the impact of drought on water availability.

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6.1 Appendices

6.1.1 Appendix 1 Household questionnaires

HOUSEHOLD QUESTIONNAIRES USED TO ACQUIRE INFORMATION FROM THE INFORMANTS SELECTED FROM THE DIFFERENT PARISHES IN KASALI SUB−COUNTY, KYOTERA DISTRICT

Dear Respondent,

I am Mukasa Joseph a student from the University of Nairobi pursuing a Master's degree in Climate Change Adaptation and I am carrying out a research study to assess the adaptive capacity of households to water scarcity during drought in Kasali sub-county-Kyotera District. Therefore, I kindly request you to be one of my respondents by answering the following questions. Your answers and opinions will be treated with maximum confidentiality and care since they are purely for academic reasons/purposes.

Your positive response will be highly appreciated.

Yours sincerely

………………………………………..

Mukasa Joseph

0779861550/0704272737

A. COMPOSITION AND CHARACTERISTICS OF HOUSEHOLD

Please fill in the household characteristics information with the interviewee.

Household's size	Gender of Household head	Age of household Head (years)	Marital status of the household head	Education level
1 – 5	Male	15-25	Single	None
6 – 10	Female	26-35	Married	Preschool
11- 15		36-45	Widowed	Primary
Above 15		46-55	Separated	Senior
		>56		Higher

6.Main house - type of walls	1.Mud & Wattle 2.Wood panel 3.Bricks 4.Stones 5.Iron sheet 6. Others (specify)…….
7.Main House - type of roof	1.Grass thatched 2. Iron sheet 3.Straw/bamboo roofed 4.Tiled
8.Household means of transport	1.Own bicycle 2.Own motorcycle 3.Hire Bodaboda 4.Taxis 5.Own track 6. Walk 7. Others specify.........
9.Current employment status	1.Full-time work 2.Part-time work 3.Self-employed 4.Homemaker (at home caring for children/adults, unpaid domestic

	duties) 5.Retired 6.Seasonal work 7.Student 8.Unemployed
10.The main source of livelihood	1.Farming 2.Employment 3.Business 4. Others specify….
11. What kind of farming system do you Practice?	1. Crop farming only 2. Livestock rearing/herding only 3.Mixed farming (Crop and Livestock production)
12. What type of agriculture do you practice?	1.Rain-fed 2.Irrigated 3.Mixed 4. Others specify…………
13. Why do you do farming for?	1.Subsistence 2.Commercial 3.Both

14a). Has there been any impact on water availability during drought?	1.Yes 2.No
b)If the answer is Yes, state the extent of the impact	1.Normal 2.Moderate
	3.Severe 4.Extreme
15a) Has there been any impact that drought has had on your livelihood?	1.Yes 2.No
b) If yes, state the extent of the impact.	1. Normal 2. Moderate 3. Severe 4. Extreme
16a). Do you collect water during the dry seasons?	1. Yes 2.No
b) If yes how long does it take to get to your Water source?	1. Less than one hour 2. One hour 3. More than one hour
17a) Do you collect water at a distance during the wet season?	1. Yes 2.No
b) How long does it take to get to your Water source??	1. Less than one hour 2. One hour 3. More than one hour

B. ADAPTIVE CAPACITY INDICATORS

Infrastructure and institutions	**Strongly disagree**	**Don't agree**	**Undecided**	**Agree**	**Strongly agree**
18. There are enough roads to facilitate the transportation of water to households during drought.					
19. There is enough electric power to supply water in this community.					
20. There are institutions that train the community to adapt to water scarcity.					
21. There are water reservoirs in the area where people have access to water during drought.					
22. There are formal and informal credit based and loans institutions.					

Technology and innovation	**Strongly disagree**	**Don't agree**	**Undecided**	**Agree**	**Strongly agree**
23. Do you have any local means of acquiring water during drought seasons?					

24. Do you know of any new technological means of acquiring water during drought?					
25. Do you have access to these new technologies if any?					
26. Are you interested in any other better means of accessing and acquiring water during drought?					
27. Do you have enough funds to acquire any new technological means of acquiring water during drought?					

Social capital	**Strongly disagree**	**Don't agree**	**Undecided**	**Agree**	**Strongly agree**
28. Do you belong to any social group?					
29. Do you have access to weather information through these groups?					
30. Do you receive training on how to conserve water during drought seasons?					
31. Do these groups encourage you to save					
32. Have you used any of these loans or savings to access water during drought?					

Income level	**Strongly disagree**	**Don't agree**	**Undecided**	**Agree**	**Strongly agree**
33. Do you have a stable income that can enable you to access water during drought?					
34. Do you have enough savings that you use to access water during drought?					
35. I have more than one source of income					
36. We have more than one person in the household contributing to the household income.					

Literacy levels /knowledge and information	**Strongly disagree**	**Don't agree**	**Undecided**	**Agree**	**Strongly agree**
37. I have knowledge on climate change.					

38. a) I receive weather change information to prepare for in advance.					
b) if yes do you understand them					
39. a) Do you have any local knowledge of predicting the weather?					
b) If yes Are they effective?					
40. a) Do you have any water sources within the community?					
b) Do you feel the changes in the quality and quantity of water resources in the last 20 years?					

C. ADAPTATION TECHNOLOGIES

41.**Adaptation strategies to water scarcity during drought**	**Yes**	**No**
Reduce the quantity of water used during drought		
Harvest water in tanks		
Abandon activities that require a lot of water e.g. farming etc.		
Migrate to urban areas for other livelihoods		
Buy water		

42. a) Do you think the above adaptive mechanism(s) used are sustainable in this era of climate change and variability?	**Yes**	**No**
b) If your answer to the question is No, state other appropriate adaptation mechanism(s).		
43. What are the major constraints that hinder your ability to adapt?	Lack of money 2. Lack of Information 3. poverty 4. Lack of credit 5. Lack of technology 6. Lack of Extension service 7. Poor transport link 8. Others…………………………………	

Thank you

6.1.2 Appendix 2 Guiding questions for Focus Group Discussion (FGD)

Village: ……………

Number of members: ……………

Composition: male………… female………youth…….

1. Do you feel the pattern of general weather changes in your community?
2. Are there any noticeable weather change patterns over the last three decades?
3. What do you think is the cause of the change?
4. Is this area prone to drought? If yes, explain with years.
5. What has been the main impact of drought on water quantity and availability?
6. How has water scarcity affected your livelihoods within the community?
7. What can you say about the intensity and frequency of the recent drought compared to historical ones if any?
8. What mechanisms are used locally to reduce the impact of water scarcity on livelihoods? Do you think they are effective? If not, how would you want them to be effective?
9. What challenges that hinder households to adapt to water scarcity impacts?
10. What communal arrangements do you have in the community to help each other during water scarcity in drought periods?
11. Do you have access to water supply programs from the government or NGOs?
12. Do you receive early warning information about drought occurrences in order to prepare?

Thank you

6.1.3 Appendix 3 Key informant interview

District Agricultural Officer, District environment officer

Name ……………………………………… Position/profession …………………

1. Has there been any form of climate change and variability in this sub-county in the last 5– 30 years? If yes explain.
2. If the answer to Q1 is yes, please explain the extent of climate change and variability?
3. What impact has climate change and variability had on the people's livelihoods in the district?
4. Which areas in the districts are prone to droughts?
5. What are the local coping mechanisms used by households to reduce the impacts of water scarcity on livelihoods?
6. Are there facilitations and supports from local government to strength individual farmers' adaptive capacity to climatic changes?
7. What are the main challenges in adapting to water scarcity in the district and how do you think they can be overcome?
8. What efforts has the district local government put in place to reduce the impact of water scarcity on households' livelihoods during drought periods?
9. Are there Capacity building opportunities available for the district leaders relating to water scarcity adaptation during drought?
10. Are there policies that improve household adaptive capacity during drought, including policies on new technology extension, infrastructure development etc.?

Thank you