

**WATER ACCESS CHALLENGES AND COPING STRATEGIES IN SELECTED
SITES OF MAKUENI COUNTY, KENYA**

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DECLARATION

I declare that this is my original work and it has not been presented anywhere else for the award of any degree.

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DEDICATION

I dedicate this study to my parents for their encouragement and support throughout the entire period of learning. Not for getting the people of Makueni County especially at Kyanguli and Kilili sub-locations which were my study sites; for their unlimited information provision during data collection. All credit goes to the Almighty God for his care and protection throughout my studies.

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God bless you all.

ABSTRACT

Makueni County is extremely vulnerable to climate change because its production systems are climate sensitive, and many people are unable to cope up with climatic stress. The aim of this study was to establish water scarcity coping strategies used by rural communities in Kilili sub-location in Makueni sub-county and Kyanguli sub-location in Kibwezi East sub-county, all located Makueni County. The broad objective of the study was to identify water sources, access challenges and coping mechanisms in selected sites in Makueni County. The study also documented institutions promoting water resources and coping mechanisms and hence water access in the selected sites of the County. The study adopted cluster sampling and simple random approach to gather quantitative data using household surveys. A total of 70 households in two selected sites were interviewed. The collected data was coded and entered into the computer for analysis using the Statistical Package for Social Sciences (SPSS) and presented using tables. Results obtained on water sources revealed that rivers were the major sources of water (78%) across the study site followed by shallow wells (31%) (SD=23.5). Most households (46%) in both sites could access water within 1-3km (SD=2.5). Five major water access problems were documented in the study sites and in overall, scarcity of water was the most common problem in both study sites (77%) (SD=9.5). In the study areas, there were five institutions which influenced coping mechanisms and uptake of adaptation measures and among them were the non-governmental organizations (NGOs) and community based organizations (CBOs). Within the study sites the commonest found institutions were the NGOs (69%) (SD=25.5) followed by CBOs (23%). The commonest technology adopted in curbing water scarcity was sand dams (71%) (SD=4.5). Results of this study can be used by the ministry of water to address water challenges in the selected sites of Makueni. Successful technologies can be rolled out to address water challenges in other dry areas in the greater Makueni County.

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LIST OF ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi Arid Lands
ASD	African Sand Dam
AWDR	Africa Water Development Report
AWM	Agricultural Water Management
FAO	Food and Agriculture organization
FEWSNET	Famine Early Warning Systems Network
GAA	Germany Agro-Action
G.o.K	Government of Kenya
GDP	Gross Domestic Product
ICID	International Commission on Irrigation and Drainage
IPCC	Intergovernmental Panel on Climate Change
IWMI	International Water Management Institute
MCIDP	Makueni County Integrated Development Plan
NDMA	National Drought Management Authority
NEMA	National Environment Management Authority
NGO	Non Governmental Organisation
RHM	Rainwater Harvesting and Management
SD	Standard Deviation

SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Program
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER ONE: INTRODUCTION

1.0 Background

There is a consensus that over the coming decades human influenced climate change will cause dramatic transformations in the biophysical systems that will affect human settlements, ecosystem services, water resources and food production; all of which are closely linked to human livelihoods, (UNFCCC, 2005, IPCC, 2001, 2007a). These transformations are likely to have widespread implications for individuals, communities, regions and nations. According to Adger (2001) the poor, natural resource-dependent rural households will bear the greatest burden of the adverse impacts.

Rural livelihoods are subject to multiple shocks and stresses that can increase household vulnerability. Water scarcity is one of the pervasive stresses that individuals and communities in rural areas have to cope with. Seasonal climate forecasts provide an indication of how variable the rainfall might be compared to past years and is therefore considered as information that could help to prepare for and adapt to water scarcity. The growing evidence of global environmental change and increased climate variability demands that adaptation options, adaptive capacity and ways to reduce risk should be prioritized (Smit *et al.*, 2000). Because water scarcity is only one stress on livelihoods, the impact of seasonal forecasts requires assessing not just agricultural activities that might change in response to forecasts, but the multiple dimensions of rural livelihoods that constrain the uptake of information, have secondary effects and determine the system's ability to handle future stress.

Since the United Nations Framework Convention on Climate Change was signed in 1992, interest in climate change has been as variable as the weather itself. As with many issues involving social, economic and environmental concerns, arguments pro and con on climate change are regularly debated and rarely resolved. While there is growing acceptance that the climate is in fact changing and that it continues to be influenced by human activity, directions for future policy, programmes and related actions are largely shrouded in controversy with a good measure of confusion. Another response to impacts from environmental change is to focus on the ability or capacity of individuals, communities and nations to handle the impacts and/or take advantage of opportunities from altered conditions (IPCC, 2013).

Climate change poses great challenges for the rural poor in developing countries who tend to rely on natural resources for their livelihoods and have limited capacity to adapt to climate change (Smit and Pilifosova, 2001; UNFCCC, 2007). Long-term changes in temperature and precipitation and increases in climate variability and extreme weather-related events are already evident in many parts of the world. It has become increasingly clear that even serious efforts to mitigate climate change effects will be inadequate to prevent devastating environmental change impacts that threaten to reverse many of the economic gains made in the developing world in recent decades. Therefore, individuals, communities, and policymakers must adapt to a new climate reality to increase resilience against future climate change, much of which remains highly uncertain (IPCC, 2007a).

African countries are particularly susceptible to climate change due to the desertification process, declining run-off from water catchments, declining soil fertility, dependency on subsistence agriculture, the prevalence of AIDS and vector-borne diseases, inadequate government mechanisms and rapid population growth (Anyadike, 2009). Greater reliance on

climate-sensitive renewable natural resources sectors such as water and agriculture which are more vulnerable to the impact of climate variation (Eboh, 2009).

The availability of water resources in Kenya has been decreasing over time as a result of persistent droughts and land-use patterns. The climate scenarios show that rainfall variability and increased evaporation due to higher temperatures will lead to further decreases in the available water (GoK, 2013). Already there are dramatic reductions in the snow and glaciers of Mount Kenya, believed to be associated with global warming. These glaciers could vanish in the next 15 years. The disappearance of the glaciers will affect agricultural activities, the availability of water for both rural and urban populations, hydroelectric production and tourist activities (Ministry of Environment and Mineral Resources, 2009). Adaptation to water scarcity is one of the most important issues facing Kenya today and rural Kenyans' livelihoods are already affected by a changing climate, (Ritho, *et al.*, 2012).

Makueni is a water scarce County due to effects of climate variation, among other factors which has led to serious degradation of the water resources in terms of quantity and quality (MCIDP, 2013). Water demand in the County is $22,113\text{m}^3/\text{d}^{-1}$ and the developed sources have an average production of $13,607\text{m}^3/\text{day}$ (MCIDP, 2013). There are two major rivers; Athi which is permanent and Thwake which is semi-permanent.

The average distance to nearest water source in Makueni County is eight Kilo-meters indicating that there is need to adopt in sustainable water use technologies. Sand and earth dams, shallow wells, bole holes and rain water harvesting are the main sources of water (MCIDP, 2013). Adaptation to climate change is considered an essential component of poverty reduction and sustainable livelihoods. Adaptation does not just involve large dams

and infrastructure; it also means local community initiatives that benefit people's livelihoods as well as address local environmental issues.

1.2 Problem statement

Makueni County is commonly comprised of an agro-pastoral community, and is characterized by high population density with majority of the communities living in the county being predisposed to the negative effects of a changing climate (FEWSNET, 2013). The changing climatic conditions have resulted in frequent and intense droughts, that subsequently has led to lack of adequate water, insufficient food, increased incidences of opportunistic diseases, increased insecurity, water resources related conflicts, reduced incomes among the households, and these are key factors that increase their vulnerability and reduces their resilience to the changing climatic conditions (FAO, 2013).

Due to water scarcity communities in the Kilili and Kyanguli walk for long distance and spend more time looking for water for their livestock and domestic use instead of engaging themselves in other income generating activities. The major water sources for domestic, agricultural and livestock use within the County are rivers, wells, seasonal rivers which have been affected by water scarcity thus affecting economic statues of the people and food security in the selected sites. This study therefore was set to fill the gap on the adaptation strategies used by rural communities using the case of water availability in Makueni sub-county and Kibwezi East sub-county in Makueni County. The residents of the study sites have been using traditional strategies to cope with climate change and impacts on water availability.

1.3 Objective of the study

The broad objective of the study was to document water sources, access and coping mechanisms in selected sites of Makueni County, Kenya.

Specific objectives

- (i) To document water sources and water access by the rural community in the selected sites of Makueni County.
- (ii) To investigate the existing water use coping mechanisms in the selected sites of Makueni County.
- (iii) To assess the influence of local institutions on the uptake of water use coping mechanisms in the selected sites of Makueni County.

1.4 Research questions

- (i) Which are the major water sources and how far do the selected rural community access them?
- (ii) What are the existing water use coping mechanisms in the selected sites of Makueni County?
- (iii) To what extent do the local institutions influence the uptake of water use coping mechanisms in the selected study sites of Makueni County?

1.5 Justification of the study

The study will shed light to what the county government and even locals may assist in solving water scarcity e.g. by emphasizing on water saving technologies. The study also will build the knowledge base to guide adaptation of rural livelihood system, create awareness on adaptation measures on water scarcity. It also allows the assessment of outcomes that

facilitate policy consideration and decision making in the face of future uncertainty. The study contributes to provision of more data on existing water challenges to water related bodies and institutions, if the information is well utilised will reduce the vulnerability of rural community and increase the opportunities for sustainable development. The study will generate knowledge on available adaptation and coping mechanisms against impacts of climate change on water resource use in Makueni County. It will also unearth underlying factors contributing to low adaptation technology uptake by the community if any.

CHAPTER TWO: LITERATURE REVIEW

2.1 Water scarcity trends in Kenya

Water is vital to life on earth and a means for navigation. It is a commodity that is consumed, and carrier of other substances or properties, such as heat, disease vectors, pollutants and energy (Jordaan, *et al.*, 1993). Water quantity and quality changes in both time and space. The problem of water quality and quantity was articulated by Jordaan, *et al.* (1993) as causing a great strain on water supply systems, especially in cities along river courses. Similarly, in 1985, at the midpoint of the international water supply and sanitation decade, it was pointed out that although 870 million people lived in urban areas of the developing world, roughly 1.6 million were rural inhabitants and approximately 22% of the urban group was lacking water supply service and 40% were without sanitation. The population represented 64% and about 85% as lacking water supply and sanitation services to the rural population, respectively (Jordaan, *et al.*, 1993). In essence, the rural inhabitants are faced with a great threat of using low quantity and quality water compared to the urban counterparts. This explains the existent problem of water quality degradation not only in the urban areas but also in the rural areas.

The problem of water pollution and quality degradation in the developing countries is increasingly becoming a threat to the natural water resources. This phenomenon is attributed to the increasing quest of these countries to attain industrialization status and diversification of the national development goals and Kenya is no exception to this phenomenon (Kithiia and Khroda, 2011). Kenya is described as a water scarce country, and yet future projections show that per capita available water currently at $650\text{m}^3/\text{year}$, will likely drop to $359\text{m}^3/\text{year}$ by 2020, as a result of population growth. This figure is far much below the global accepted value of $1000\text{m}^3 \text{Year}^{-1}$ per capita level. Urgent action is therefore needed to increase the

capacity of the water sector to improve the availability and accessibility of clean and safe drinking water (GoK, 2007). Many Kenyans especially in the rural areas have limited access to quality water. They walk for long distances in search of this precious commodity and use it raw and untreated from rivers, lakes and dams. The untreated water is not only turbid, but may also contain disease causing bacteria and in some cases chemicals. The problem is further compounded by the seasonal fluctuations of water availability which is more correlated to the seasonal patterns of rainfall in most parts of the country (GoK, 2010).

Water scarcity is already having profound impacts in Kenya and there is great concern that the fragile ecosystems (humid/sub-humid and dry lands areas) will undergo noticeable changes with profound effect on rural communities (GoK, 2007). This will require actions and approaches, notably in the arid and semi-arid area of the country and some of the highland humid areas (FAO, 2014).

Agriculture is the mostly affected sector by water scarcity and leads to minimal production. Rural communities, who form the majority of agricultural producers in Kenya, are highly vulnerable due to these changes (IPCC, 2013). In 2011, for instance, maize production in Eastern Province, Makueni County included dropped by 8% .The poor harvest was caused by early cessation of the 2011 short rains which was attributed to changing climatic conditions (GoK, 2013). To address the climate change impacts, Kenya has incorporated climate change adaptation strategies in its national planning documents (GoK, 2013). The climate change adaptation strategies pursued in Kenya have been classified as short-term and long-term measures. Some of the short term measures include conserving water, irrigation, constructing cattle troughs in various parts of the country for watering animals, providing seeds and fertilizer to farmers to improve production, implementing programs that provide emergency

food supplies to vulnerable people, and providing emergency relief to hard-hit livestock keepers during drought season (FAO, 2013). Some of the long-term measures include sensitizing communities about efficient and effective use of water, supporting and encouraging the use of rainwater harvesting techniques, de-silting or building new water pans / dams, (FAO, 2014).

2.2 Water sources in Makueni County

Makueni is a water scarce County (MCIDP, 2013). Catchment degradation is undermining the limited sustainable water resources base in the country (Vision 2030). Degradation of both surface and ground water resources through over-abstraction and illegal abstraction, among other factors has led to serious degradation of the water resources in terms of quantity and quality (MCIDP, 2013).

Athi is the biggest river and the only permanent river in the County. Other big rivers include Kaiti, Muuoni and Kikuu, all of which are seasonal in the County. There are four protected springs and 117 boreholes. Households with piped water are 1,2671 and 2,7752 households have access to potable water. There are 289 water pans and 159 surface dams (MCIDP, 2013). The water demand in the County is 22,113m³/day and the developed sources have an average water production of 13,607m³/day. There are 278 earth dams with a storage capacity of 3,265,543M³ while the sand dams are 118. (MCIDP, 2013).

There are 159 water supply schemes with a production capacity of 1360.7m³/hour and the average distance to nearest water source is eight Kilometers indicating that there is need for initiating more water projects. Athi River which is perennial passes through the County and can be used for development of major water supply schemes. Sand and earth dams are used in

water harvesting. Due to perennial water shortages, the local communities have picked up the practice such as roof catchments and installation of and storage tanks to harvest rain water. (MCIDP, 2013).

The main sources of water are perennial rivers, shallow wells, piped water sources, dams, springs often found in hilly masses, bore holes, seasonal streams and sandy river beds which are only available as long as the weather remains favourable (Mutai and Ochola, 2011). This highlights the need for adequate access and availability of quality water, whereby through enhancing interventions would provide an opportunity for the vulnerable communities to prepare and mitigate the drought impacts, such as the scarcity of water which are as a result of a changing climate.

2.3 Effects of water scarcity on rural communities

Trends in water use and demand are often a guide to the availability of water in terms of both quantity and quality. In many instances, an increase in water demand and use is directly proportional to deterioration in water quality. The amount of waste discharged tends to increase with rising water demand, although the relationship depends in detail on the amount of water and the specific use involved. The amount of water in a river depends on the type and number of water abstraction facilities along the course, the number of tributaries, amount of rainfall and distribution, soil type, temperature and the shape of the drainage basin, as well as the population structure. The nature and extent of human activity, be it industrial, agricultural or both, in turn determine the water quantity and the water quality status. Clearly, in order to avoid the dangerous consequences of serious water shortage, there is a need to properly understand the amount of water required by any development projects planned (Kithia, and Ongwenyi, 1997).

At the global level about 1 billion people are locked out of having access to safe water due to poverty, inequality and government failure. In Kenya, largely due to recurrent droughts, millions of families that rely on crops and livestock are threatened and thousands of people die each year as a result of thirst and hunger. According to World Bank (2010), the mortality rates of adult males, adult females, children under five, and infants has increased from 1990 to 2008. In Kenya, the water crisis has severely affected millions of lives in many ways as contaminated water resources are extremely unhealthy and typically result in multiple illnesses.

Rural community are particularly vulnerable to changes in the climate that reduce productivity and negatively affect their weather-dependent livelihood systems. For instance, in Malawi, frequent droughts and floods have eroded assets leaving people more vulnerable to disasters (Gandure and Alam, 2006) such as water and food insecurity, diseases and land degradation. Evidence strongly suggests that increased droughts and floods may be exacerbating poverty levels, leaving many rural communities trapped in a cycle of poverty and vulnerability to diminishing resources (Phiri, *et al.*, 2005). Water scarcity is already a major problem in arid and semi-arid areas of SSA (Rijsberman, 2006). These areas are mainly inhabited by communities who practice farming and both agro-pastoral and pastoral activities communities.

In most countries, the agriculture sector is the predominant consumer of water. Historically, large-scale water development projects have played a major role in poverty alleviation by providing food security, protection from flooding and drought, and expanded opportunities for employment. In many cases, irrigated agriculture has been a major engine for economic

growth and poverty reduction (IPCC, 2013). However, at the same time, poor communities have tended to suffer the greatest health burden from inadequate water supplies and, as result of poor health, have been unable to escape from the cycle of poverty and disease (FAO, 2011). Thus, growing scarcity and competition for water stand as a major threat to future advances in poverty alleviation, especially in rural areas. In semi-arid regions, increasing numbers of the rural poor are coming to see entitlement and access to water for food production, livestock and domestic purposes as more critical than access to primary health care and education (UN-WATER, 2003)

2.4 Agricultural water use

At the start of the twenty- first century, agriculture was using a global average of 70 percent of all water withdrawals from rivers, lakes and aquifers. The Food and Agriculture Organization (FAO, 2006) anticipates a net expansion of irrigated land of some 45 million ha in ninety-three developing countries (for a total of 242 million ha in 2030) and projects that agricultural water withdrawals will increase by some 14 percent from 2000 to 2030 to meet future food production needs. This over reliance of surface water on agricultural activity will lead to shortage of water in many households. The analysis indicates a projected annual growth rate of 0.6 percent, compared with the 1.9 percent observed in the period from 1963 to 1999 (IPCC, 2007).

Rwanda is about 165,000 hacteres of wet lands and over 50% of this land is used for agriculture (FAO 1998), cultivated Dambos (England wetlands in Malawi, Zambia, Zimbabwe) comprise about 10% of the total Dambo area in this countries (FAO, 1995). Tanzanias wetlands are mostly used for crop production and grazing (Kalinga and Shaya, 1998). Masiyandima *et al.*, (2003) based on a case study of four Southern African countries

(South Africa, Swaziland, Zibambwe) found that wetlands have wide range of uses including cropping, livestock grazing, livestock watering and domestic use. Crops produced include cereals, variety of vegetables, spices and fruits for farmers own consumption, for sale in local market and export. According to Meinzen-Dick and Rosegrant (1997) regulated development of wetlands for irrigated gardens can provide an opportunity for improved food security through increased food productions in Africa.

As UNEP (2013) stated “the availability of and access to fresh water is an important determinant of patterns of economic growth and social development”. World Bank (2006) reiterated that in recent years, agricultural water has helped meet rapidly rising food demand, and has contributed to the growth of farm profitability and poverty reduction in many countries. In SSA, where water scarcity is a major challenge to rural development and poverty reduction, however, the story is different. Since water availability is variable in space and time, rural well-being is dependent on its supply, use, disposal, and reuse (ICID, 2001). Investment in agriculture requires the assurance of irrigation to overcome the vagaries of the natural availability of water (ICID, 2001, IWMI, 2005).

Despite the importance of irrigation for economic growth, SSA exploits only a meagre proportion of its potential, primarily due to high investment costs and shifting investment priorities of development agencies (Peacock, *et al.*, 2007). Of the total amount of water withdrawn, 85 percent is used for agriculture, 9 percent for community water supply, and 6 percent for industry (UNECA, 2001). At both continental and sub-regional levels, the withdrawals are low in relation to both rainfall and internal renewable.

2.5 Impacts of water scarcity on agricultural activities.

The projections of future environmental change are uncertain especially in relation to scenarios of future rainfall, floods and droughts. However, temperature projections are generally more reliable. A warming throughout sub-Saharan Africa is projected to be larger than the global annual average (IPCC, 2007b). As regards rainfall, some model predictions indicate that East Africa region is going to have increased rainfall events (IPCC, 2007a), while other recent research suggests that local circulation will result in depressed precipitation instead (Funk *et al.*, 2008). Nonetheless, the climate is changing already and a striking consensus is that the future climate is unlikely to be the same as at present. Thus there is need to apply precautionary principle on the grounds that the costs of not acting are likely to be incalculably high.

Spatial and temporal variation of precipitation and increased temperatures are the main environmental related drivers, which impact agricultural production (ODI, 2009). Increased temperature levels will cause additional soil moisture deficits, crop damage and crop diseases; unpredictable and more intense rainfall; and higher frequency and severity of extreme climatic events (Boruru, *et al.*, 2011). Similarly, the drivers of environmental change have the potential of altering plant growth and harvestable yield through carbon dioxide fertilization effects (UNDP, 2012). Free Air Carbon Enrichment (FACE) experiments indicate productivity increases in a range of 15 – 25% for C3 crops (wheat, rice and soya beans) and 5 – 10% for C4 crops (maize, sorghum and sugarcane). Higher levels of carbon dioxide also improve water use efficiency of both C3 and C4 plants (Lotze-Campen & Schellnhuber, 2009). However, there is uncertainty about the magnitude of the positive effects of enhanced carbon dioxide concentration.

Water scarcity will interlock with people's life-worlds differently for different reasons. The geography of a people's location relative to other people may position them more acutely in harm's way when climate change ramifications unfold (Boruru, *et al.*, 2011). In mid to high latitude regions, moderate local increases in temperature can have small beneficial impacts on crop yields, while in low latitude regions, such moderate temperature increases are likely to have negative yield effects (Iglesias, 2006; Aydinalp and Cresser, 2008; IAASTD, 2009). This will significantly increase yield variability in many regions of the world, and result into polarization of effects with substantial increases in prices and risk of hunger amongst poorer nations (Iglesias, 2006; UNDP, 2012). However, through advance preparation and careful management of agricultural systems, these risks could be substantially reduced. Recent studies show that for each 1°C rise in average temperature, dry-land farm profits in Africa will drop by nearly 10% (FAO, 2008). Similarly, yields from rain-fed crops could be halved by 2020, and net revenue from crops could fall by 90% by 2100 in some countries in Africa (UNFCCC, 2007).

Extreme climatic events of drought and floods are a threat to agricultural system and could bring about both chronic and transitory food insecurity. This is because many crops have annual cycles and yields that fluctuate with climate variability, particularly rainfall and temperature (FAO, 2008). As a consequence of climate change, rural areas that depend on rain fed agriculture will become more vulnerable to food insecurity.

Water scarcity will be aggravated by the looming climate change. By 2020, yields from rain-fed agriculture could be reduced by as much as 50 percent in some countries (IPCC, 2007a). This will adversely affect food security and further exacerbate malnutrition and poverty, especially in SSA. The vulnerabilities and anticipated impacts of climate change will be

observed at different scales in different countries (IPCC, 2001). Where consistent long-term climatic data are available, they indicate a trend towards reduced precipitation in semi-arid to arid regions (IPCC, 2001). Instrumental data and climate model simulations indicate an imminent water crisis in large parts of Africa (IPCC, 2007c).

Water scarcity will have a major impact on the baseline environmental characteristics and hydrological cycle (World Bank, 2009) on which ecosystems and livelihoods are based. A common feature in rainfall patterns as impacted by climate change is greater variability in cycles (IPCC, 2001). In SSA, most areas are characterized by low and erratic rainfall, concentrated in one or two short rainy seasons. This results in high risk of droughts, intra- and off-seasonal dry spells, and frequent food insecurity.

2.6 Coping mechanism to impacts of water scarcity

In many cases, adaptation activities to water scarcity are local, district, regional or national issues rather than international (Paavola and Adger, 2005). Because communities possess different vulnerabilities and adaptive capabilities, they tend to be impacted differently, thereby exhibiting different adaptation needs. As a result, adaptation largely consists of uncoordinated action at household and organization levels. But it may also involve collective action at the local, national, regional and international levels and cross-scale interaction where these levels meet (Paavola and Adger, 2005).

The vulnerabilities of water scarcity occur at various scales (Adger, *et al.*, 2005), and hence successful adaptation will depend on actions taken at different levels. This has been defined by Paavola and Adger (2005). At the national level where there is formulation of climate change policy geared toward vulnerable sectors and community coping mechanisms,

development of policies and institutions that support adaptation at community levels. Introduction of collective security arrangements such as farmers' cooperatives and community-based organizations (CBOs), provides knowledge, technology, policy, institutional and financial support for the vulnerable communities, There is need for prioritization of local adaptation measures and provision of feedback to stakeholders (Paavola and Adger, 2005)

Different communities are affected differently by climate change and variability and, depending on their adaptive capacities, have developed coping strategies. This explains the region-to-region, village-to-village and household-to-household variation in coping strategies. According to Cooper *et al.* (2006), rural communities cope with climate variability, but can adapt differently to climate change as varied as the agro-climatic zones and expected impacts on peoples' livelihoods due to climate change. Depending on subjective vulnerability, affected rural communities logically make certain adjustments in their choices of technologies and production systems. Cooper *et al.* (2006) grouped such coping strategies in two categories.

According to Cooper *et al.* (2006) investments to enhance tolerance for drought stress, improve water productivity and integrate management of land and water resources, have the potential to reduce vulnerability to climate shocks while improving productivity. It is imperative that improving AWM, especially for rural community in SSA, is one of the key ingredients in any sustainable adaptation strategy. Adoption of integrated watershed management in India contributed to improved resilience of agricultural production and water security despite the high incidences of drought (Cooper, *et al.*, 2006).

Some of the adaptation strategies for rural communities in West Africa are the use of shallow wells and hand-dug wells to supplement the shortfall in water for dry-season irrigation, use of soil moisture improvement techniques such as Zai, semi-moons and mulching, which are practiced in northern Ghana, Burkina Faso and Mali as adaptation strategies, as well as efficient use of water through drip irrigation and the choice of high yielding and high-value crops (FAO, 2013). The use of drought-resistant crop varieties and the improvement of on-farm irrigation efficiency through the use of better water application, Bunds, agro-forestry and rainwater harvesting have all been effective adaptation strategies to water scarcity and climate change variability. The alternative use of waste water for irrigation is another strategy for adaptation to climate change on water availability (cooper, *et al.*, 2006).

2.7 Rainwater harvesting and management

Rain is the primary source of water known in the hydrological cycle, while rivers, lakes and ground water are all secondary sources. In present times, there is heavy dependency on such secondary sources of water and in the process, it is forgotten that rain is the ultimate source that feeds all these secondary sources (CSE, India 2003). Rainwater harvesting (RWH) is making optimum use of rainwater at the place where it falls so as to attain self-sufficiency in water supply without being dependent on remote water sources (UN-HABITAT, 2004). It is the intentional collection, storage and management of rainfall and other various forms of precipitation from different catchment surfaces.

Rainwater harvesting is an ancient practice and has been in parts of the world for over 4000 years (Worm and Hattum, 2006). Rainwater harvesting in Asia dates back to 10th Century (Global Development Research Center, 2002) and is also popular in rural Australia, parts of India, Africa and parts of the United States. It was widely used for the provision of drinking

water in the rural areas in Europe and Asia. Since 1990s, urban RWH has also been on the rise in various parts of the world. For example, Singapore which has limited resources in terms of land and water has turned heavily to rainwater harvesting. About 48% of its land is used as water catchment area (Appan, 1997). Consequently, about 86% of its population live in high-rise buildings. Water collected from roofs in the urban areas is harvested and stored for non-potable uses. This has saved about 4% of the water used in Singapore. Despite the recent developments in expansion of rainwater catchment systems in Africa, adoption of RWH is slower as compared to other continents.

According to Mati (2007), various rainwater harvesting technologies have been in use for millennia and new ones are being developed all the time. These can be classified as:

Macro-catchment technologies. This is a system that involves the collection of runoff from large areas which are at an appreciable distance from where it is being used. These technologies handle large runoff flows diverted from surfaces such as roads, hillsides, pastures. Hillside sheet/rill runoff utilization, rock catchments, sand and earth dams are examples.

Micro-catchment technologies are those that collect runoff close to the growing crop and replenish the soil moisture. Micro-catchment technologies are mainly used for growing medium water demanding crops such as maize, sorghum, groundnuts and millet. Examples of these technologies are Zai pits, strip catchment tillage, contour bunds, semi-circular bunds and meskat-type system. Rooftop harvesting technologies have the advantage to collect relatively clean water.

For small-scale catchments, rainwater harvesting can be categorized according to the type of catchment surface used and, by implication, the scale of activity (Nissen-Petersen, 1999).

Overdependence on secondary sources of water coupled with the increasing climate change, has made water to be a scarce resource in the world with about 783 million people in the world (11% of the world's population) having no access to safe water. Lack of safe water and sanitation costs sub-Saharan Africa around five percent of its Gross Domestic Product each year. Kenya being in the sub-Saharan Africa is no different like other arid and semi arid lands (ASAL) parts of Kenya, Makueni County located within the Eastern Region of Kenya has over the years been ravaged by decades of hunger and starvation. The County is characterized by hot and dry climate for most of the year. Temperature ranges between 12⁰c and 32⁰c. Two rainfall seasons with an average annual rainfall rang of 150 to 650 mm are experienced with the long rains occurring in March/April and the short rains in November/ December (Makueni County's Integrated Development Plan (MCIDP, 2013).

Rainwater harvesting has been in existence for many decades as a way of augmenting available water resources in the world. In the years of its existence, rainwater harvesting has positively impacted life, agriculture and economy. Despite these known benefits of rainwater harvesting, Makueni County's population is slowly adopting rainwater harvesting technologies. However water scarcity still remains a major constraint to life and economic development in the County. Although clean and safe water is a treasured commodity, many people in Makueni County do not have access to it. People from the hilly places in the County rely on springs and shallow wells to get their water for domestic use whereas in the low lands they mainly use boreholes, sand dams and earth dams as their sources of water.

In semi-arid and arid areas where rainfall is low and predicted to decline further, in situ moisture conservation either through conservation agriculture or construction of rainwater control and management structures and rainwater storage in farm ponds, water pans, sand/sub-surface dams, earth dams, tanks for supplemental irrigation are gaining prominence (Ngigi, *et al.*, 2008). Either through their own experiences or with technical assistance from development agents especially local NGOs and development partners, rural communities are adopting a variety of innovative RHM technologies to cope with recurrent droughts (Mati, *et al.*, 2008a and 2008b, Ngigi, *et al.*, 2008). For instance, in the Lare division of Nakuru district in Kenya, (Blank *et al.*, 2007) an adoption rate of farm ponds at about 390 percent was reported over a period of six years (1998-2004). In the same area, Malesu, *et al.* (2006) found nine farm ponds per km² using satellite imagery, with most households possessing ponds. There has been notable improvement in water security, crop production, diversification, and rural community incomes.

2.8 Conceptual framework

Water resources have declined in the recent past due to human activities; like over extraction of ground water and degradation of water catchment areas. This has led to severe water scarcity for both domestic and livestock purposes negatively affecting rural community. The community are made to change their use and management of water resulting to adopting to various strategies and technologies hence conservation of resources.

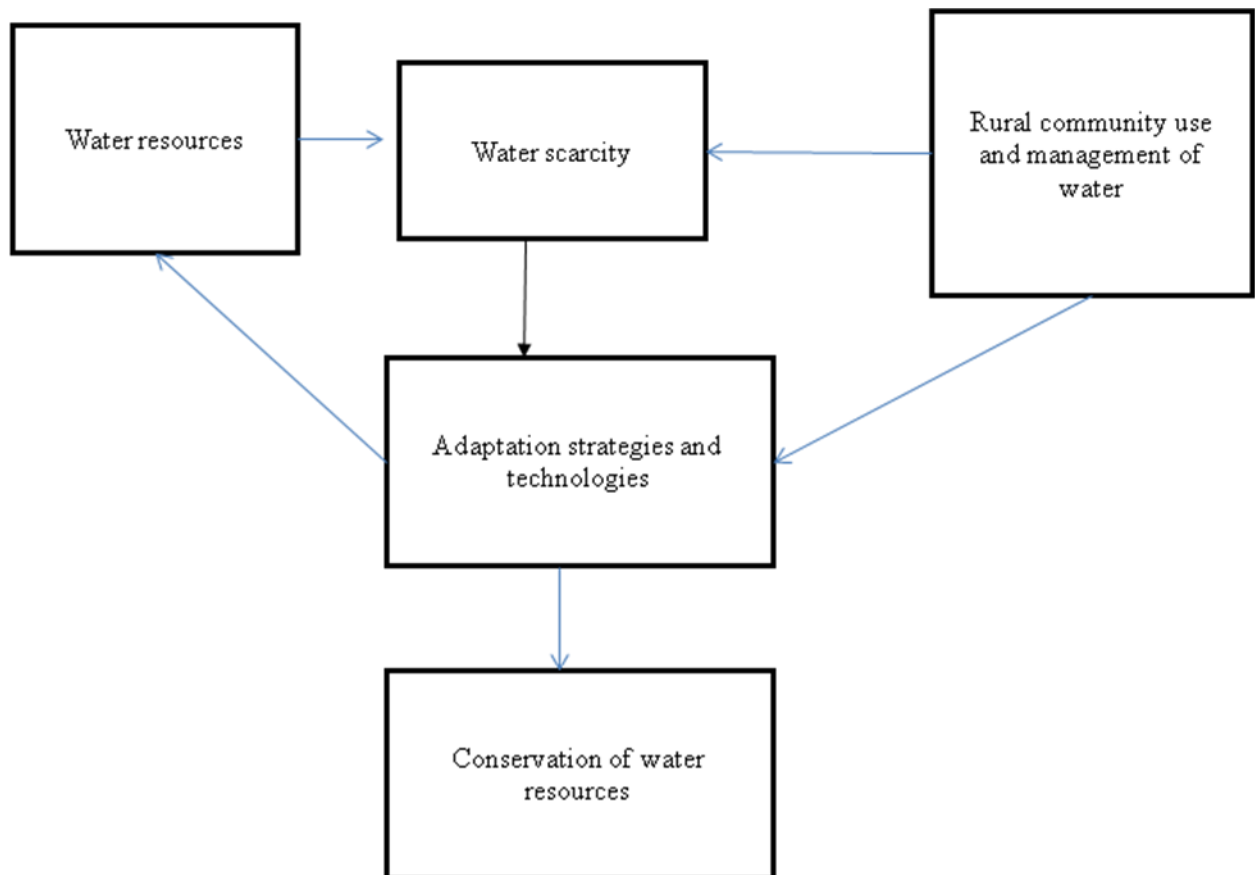
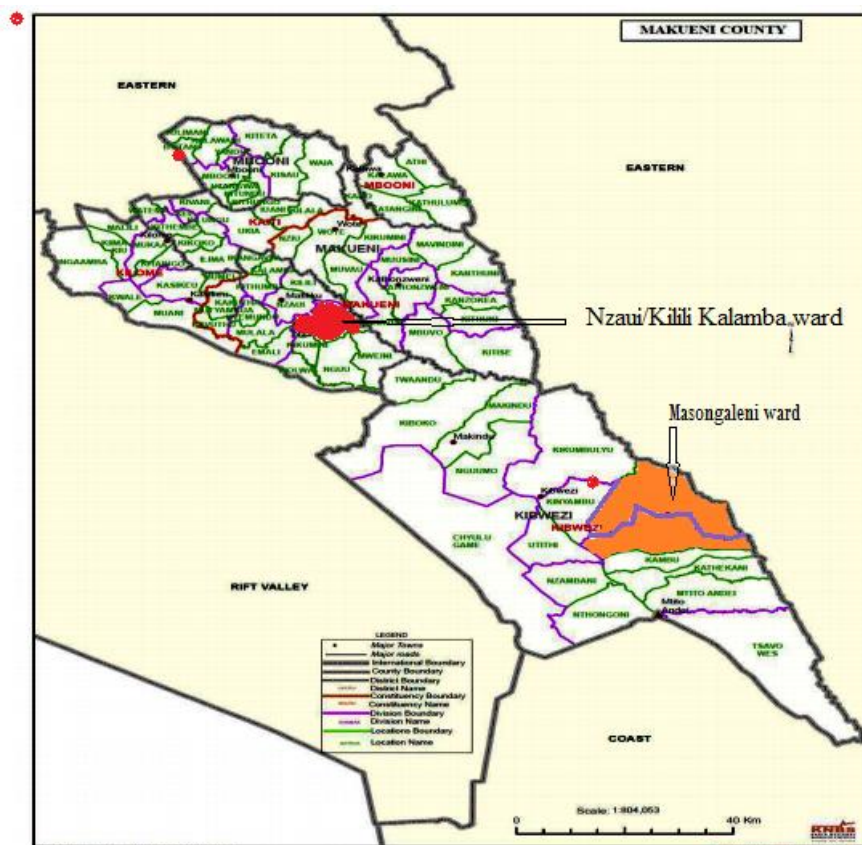


Figure 2.1: Conceptual framework

CHAPTER THREE: METHODOLOGY

3.1 Study Area

The study was carried out at Masongaleni ward Kibwezi East sub-county and Nzau/Kilili/Kalamba ward in Makueni sub-county in Makueni County. The choice of the study site was based on several considerations emanating from the research problem. There is increasing water scarcity within the study areas that had affected the rural communities. The evident impacts of water scarcity being experienced in the County and in the study areas, there is existence of a high number of water based initiatives which are aimed at managing the negative impacts on the community (MCIDP, 2013).



Source: Kenya National Bureau of Statistics, 2010

Figure 3.1: Map of Makueni County showing the study area (Source: Kenya National Bureau of Statistics, 2010)

3.2 Physiographic conditions

The area is generally arid and semi-arid with annual temperature ranging between 27°C and 34°C and the area has two rain seasons. The long rain season is between March and April and the short rains between November and December. The rainfall pattern is erratic and ranges between 400 and 1000 mm per year. The altitude of the area ranges between 400 and 900 metres above sea level. The area is characterized by low lying grassland with scattered acacia trees and shrubs and is suitable for rain fed agriculture. The lowlands which constitute the largest part of the area receive erratic rainfall. The land is mostly suitable for arable farming and livestock rearing (MCIDP, 2013).

3.3 Population and demographic characteristics of the study areas

The study area covered two wards, Masongaleni which has five locations and Nzau /kiliki/kalamba ward which has four locations. Their population and demographic characteristics are presented in Table 3.1 and 3.2.

Table 3.1: Population and demographic characteristics of Masongaleni ward

Ward	Sub-location	Total pop.	Number of Households
Masongaleni	Kyanguli	1750	336
	Masimbani	6586	1310
	Masongaleni	5982	1235
	Mukaange	11210	2312
	Ulilinzi	6742	1315
Grand total		32,270	6508

Table 3.2: Population and demographic characteristics of Nzaui/kilili/kalamba ward

Ward	Sub-location	Population	Number of households
Nzaui/kilili/kalamba	Kilili	1903	378
	Wee	1300	248
	Kathatu	2015	382
	Mulenyu	1140	251
Grand total		6,358	1,259

Source: Republic of Kenya (2010).

3.4 Sampling method

The study adopted cluster sampling and simple random approach to gather quantitative data for the household survey. Cluster sampling method was used because it allows for a more cost effective approach to the quantitative survey and still takes the population of individual sub-location into account, and ensures that there is adequate distribution of respondents across the population studied (Ranjit, 2005). The area was divided into two sites. Within each site, random sampling was carried out to select the households.

3.4.1 Sample size and sampling procedure

Two data sets were collected through household and key informant surveys in order to meet the objectives of the study. Different sampling methods were used to identify respondents for each data set using questionnaire and focused group discussions.

3.4.2 Data collection

Data collection involved reconnaissance survey and site selection through consultation with local administration. Secondly administration of questionnaires on water sources and water access by the rural community, existing water use coping mechanisms and factors influencing water use coping mechanisms and uptake of adaptation of technologies by the rural community. This was done by random sampling in the study area. Lastly purposive sampling was used in administration of key informant's questionnaire on water conservation strategies.

The sampling frame comprised of 336 households in Kyanguli and 378 households in Kilili sub-locations. The total number of households interviewed was determined by the sample size of 10% rule at each sub-location in the two wards (Mugenda and Mugenda, 2003). In the households' survey, combined random walk method was used in which Kyanguli and Kilili sub-locations were sampled having 33 and 37 households, respectively. In the whole study area a total of 70 households were interviewed. Purposive sampling was used in choosing the key informants to interview in the survey. This included institutions that deal with water issues in the area of study.

3.5 Research Design

The study employed a survey research design. According to Orodho (2005), Survey concerns describing, recording, analysing and reporting conditions that exist or have existed. The survey design was relevant to this study as the research reported on socio – economic characteristics of the respondents and study area and the adaptation to water availability.

3.6 Methods of data collection

Various methods were employed in data collection and analysis. These included use of questionnaires and interviews. Questionnaires were administered to households in selected sites through random sampling. The questionnaire was used as a guide in household interviews so as to attain the set objectives. The questionnaires were not issued to the household members to avoid poor data entry. To validate data collected using questionnaires, interviews were conducted on various key informants including those institutions dealing with water conservation technologies. Only top management were interviewed and at this stage questionnaires were given to them because they have knowledge to fill the questionnaires. Secondary data was used to provide information on what has already been done in relation to the study and to relate the findings based on the study objectives

3.7 Data analysis

The collected data was coded and entered into the computer for analysis using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel. On qualitative data, thematic analysis was done derived from the administered questionnaires. The main themes and patterns in the responses were identified and analysed to determine the adequacy, usefulness and consistency of the information. The data involved people responses and opinions.

Quantitative data was analysed using descriptive statistical tools such as frequencies, percentages and means accordingly. The results of data analysis were presented in tables.

CHAPTER FOUR: RESULTS

4.1: Household socio-economic characteristics

The common socio-economic characteristics of the study area referring to all members and heads of the selected households are presented in Table 4.1. The study established that 82.25% of the households sampled were male headed compared to female headed households (17.65%). The level of education was very low since primary level had a mean percentage of (72.5%) while university was at (1.4%). Occupations played a key role towards water use commonly in agricultural practices (55.48%). According to the survey the total households interviewed indicated that the highest household size lie within 4-6 (50.44%) > 7-9 (23.42%) > 1-3 (14.65%) > 10-12 (11.46%) in study area.

Most of the land size in Kilili was below 3 acres (43.24%), while in Kyanguli land was commonly owned at 4-6 and 10-12 acres (27.27%). The popular building materials are iron-sheets for roofing and bricks for walls. Iron-sheets for roofing account for 90.90% in Kyanguli and 86.48% in Kilili, followed by thatched houses at 9.09% in Kyanguli and 35.13% in Kilili. Households that had houses with brick walls accounted for 84.84% in Kyanguli and 72.97% in Kilili

Table 4.1: Selected household socio-economic characteristics (%) (N=70)

Socio-Economic Variable	Sub-location		
	Kilili	Kyanguli	Mean
Gender of household head			
Male	91.8	72.7	82.25
Female	8.1	27.2	17.65
Average age of household head			
Husband	46.05	42.15	44.1
Wife	41.86	44.48	43.17
Level of education			
Primary	78.4	66.6	72.5
Secondary	13.5	24.2	18.9
Tertiary	5.4	9	7.2
University	2.7	0	1.4
Occupation			
Farmer	59.45	51.51	55.48
Business	27.02	39.39	33.205
Driver	8.10	-	8.10
Civil servants	2.70	9.09	5.895
Masonry	5.40	-	5.40
Carpenter	2.70	-	2.70
Household size			
1-3	8.10	21.21	14.655
4-6	67.56	33.33	50.445
7-9	13.51	33.33	23.42
10-12	10.81	12.12	11.465
Land Size (acres)			
Below 3	43.24	9.09	26.165
4-6	27.02	27.27	27.145
7-9	13.51	21.21	17.36
10-12	16.21	27.27	21.74
Above 12	-	15.15	15.15
House roof type (households)			
Thatched	35.13	9.09	22.11
Iron sheets	86.48	90.90	88.69
House wall type			
Mud	40.54	15.15	27.845
Bricks	72.97	84.84	78.905

4.2: Water sources and water access by the rural community

Results obtained on water sources revealed that rivers, shallow wells, boreholes, sand dams, roof catchment and springs were the main sources of water in the study sites. However, majority of the households obtained water from rivers (78%), followed by shallow wells (31%) (SD=23.5), boreholes (28%), sand dams (24%) and springs (11%). Rivers (94%), shallow wells (55%), sand dams and also roof harvesting (42%) were the major sources of water at Kyanguli. In Kilibi, rivers (62%) and boreholes (43%) were the main sources of water (Table 4.2).

Table 4.2 Water sources in selected sites (%)

Water source	Sub-locations			
	Kilibi	Kyanguli	Mean	SD
1. Rivers	62	94	78	16
2. Shallow wells	8	55	31	23.5
3. Boreholes	43	12	28	15.5
4. Sand dams	5	42	24	18.5
5. Roof catchment	5	42	24	18.5
6. Spring	11	0	11	11

Overall, most households (46%) in both sites got water within 1-3km (SD=2.5) away from their homes. In Kilibi sub-location, majority of households got water within less than 1km (46%) while at Kyanguli majority got water within 1-3km (48%) and 4-5 km (27%) (Table 4.3).

Table 4.3 Water access in study sites (%)

Water access		Sub-locations			
		Kilili	Kyanguli	Mean	SD
Distance					
1.	Less than 1 km	46	9	28	18.5
2.	1-3 km	43	48	46	2.5
3.	4-5 km	3	27	15	12
4.	Over 5 km	5	15	10	5

The study established that there was change in distance for water access in the study sites.

Kyanguli was highly affected with (70%) compared to Kilili with (43%) (Table 4.4)

Table 4.4: Distance changes in selected sites (%)

Response s	Sub-location			
	Kilili	Kyanguli	Average mean	SD
Yes	43	70	56.5	19.1
No	56.7	30	43.4	18.9

The impact of distance change in study sites resulted to increased distance for water access which was at (66%) Kyanguli and (27%) in Kilili. The cost of water also increased with Kyanguli having (56%) and Kilili (22%). The last impact was water quality and quantity with Kilili having (24%) and Kyanguli (3%) (Table 4.5)

Residents in the study sites reported that there has been increase in distance to water sources. This was reported by 66% and 27% of the residents of Kyanguli and Kilili, respectively. The residents also reported that the increased distance resulted to increases in water cost, which was reported by 56% and 22% of the residents in Kyanguli and Kilili, respectively. Further the

residents reported the increased distance to water sources have resulted to increased incidences of poor water quality at Kilihi (24%) and Kyanguli (3%).

Table 4.5: Impacts of distance change in selected sites (%)

Impact	Sub-location			
	Kilihi	Kyanguli	Mean %	SD
Increased distance	27	66	46.5	27.6
High water cost	22	56	39	24.
Quality and quantity	24	3	13.5	14.8

There were five major water access problems indentified in the study area. These included increased distance, high cost of water, dirty water, water scarcity and conflict with neighboring communities. In overall scarcity of water was the commonest problem in both study sites (77%) (SD=9.5), followed by dirty water (62%), increased distance (45%), high cost of water (44%) (SD=14) and the least was conflict with neighboring communities (43%). In Kilihi the major problem was scarcity of water (86%) while the least was increased distance (27%) compared to Kyanguli had dirty water (88%) and (67%) water scarcity (Table 4.6).

Table 4.6 Problems encountered in accessing water in the selected study sites (%)

Water access problems	Sub-locations			
	Kilili	Kyanguli	Mean	SD
1. Increased distance	27	64	45	18.5
2. High cost of water	30	58	44	14
3. Dirty water	35	88	62	26.5
4. Scarcity of water	86	67	77	9.5
5. Conflict with neighbouring communities	43	0	43	43

4.3: The existing water use coping mechanisms

Water use coping mechanisms included use of water harvesting structures, soil conservation techniques, diversification of crop types and varieties, irrigation, water reuse, reducing number of livestock and reduced water usage. The commonly used water coping mechanisms included soil conservation (85%) (SD=9), water reuse (71%), reduced livestock (64%), reduced water usage (55%) and crop diversification (54%) (SD=24.5). Major water coping mechanisms at Kyanguli included soil conservation (94%), water reuse (88%), reduced livestock (82%) and the minimum was irrigation (3%); while at Kilili the major technologies were reduced water usage (89%), soil conservation techniques (76%), water re-usage (54%) and the minimum was building water harvesting structures (11%) (Table 4.7).

Table 4.7 Water use coping mechanisms in study sites (%)

Water use coping mechanisms	Sub-locations			
	Kilili	Kyanguli	Mean	SD
1. Build water harvesting structures	11	24	18	6.5
2. Use of soil conservation techniques	76	94	85	9
3. Diversification of crop types and varieties	30	79	54	24.5
4. Irrigation	30	3	16	13.5
5. Reusing water	54	88	71	17
6. Reduced number of livestock	46	82	64	18
7. Reduced water usage	89	21	55	34

According to the results obtained in the study sites, Kyanguli had the highest % of duration at which the coping mechanisms were in place having (56%) and Kilili (41%) for the duration of more than five years. Between duration of 2-3 years Kilili had 46% compared to Kyanguli (15%). For the duration of 4-5 years in which the coping mechanisms were in place for the study sites Kyanguli had highest percentage (24%) and Kilili (14%) (Table 4.8)

Table 4.8 Duration for the use of water coping strategies in selected sites (%)

Years	Sub-locations			
	Kilili	Kyanguli	Mean	SD
2-3	46	15	30.5	21.9
4-5	14	24	19	7.07
More than 5	41	56	48.5	10.6

4.4: Influence of local institutions on the uptake of water use coping mechanisms in the selected sites

In the study areas, there were five categories of institutions which influenced coping mechanisms and uptake of adaptation measures (Table 4.9). These included non-governmental organizations, community based organizations, government ministries, individuals and private sector. Within the study sites the commonest was the None Governmental Organizations (NGOs) (69%) (SD=25.5), followed by Community based Organizations (23%) and the least was Government ministries (17%) (SD=1) (Table 4.9). With respect to site Kyanguli had (95%) NGOs, (91%) individual and the least was private sector (3%). Kilibi had NGOs (43%), CBOs (38%) and the least being government ministries (16%).

Table 4.9 Awareness on the presence of institutions influencing the uptake of water use coping mechanisms in the selected study sites (%)

Institutions	Sub-locations			Mean	SD
	Kilibi	Kyanguli			
1. NGOs	43	94		69	25.5
2. CBOs	38	6		22	16
3. Government ministry	16	18		17	1
4. Private sector	0	3		3	3
5. Individual	0	91		91	91

The study revealed the presence of three institutions promoting adaptation of water scarcity technologies and capacity building in the study sites. These institutions included: NGOs, CBOs and Government Ministry as shown below (Table: 4.10).

Table 4.10 Institutions in selected study sites

Institution	Sub-location		
	Kilili	Kyanguli	Technologies
1.NGOs	-African Sand Dam -Utooni	-German Agro-action -World Vision -African Sand Dam	-Roof-catchment -Zai pits and RHM -Sand dams
2.CBOs	-Kyeni Women Group	-Muliluni women Group -Thange self Help Group -Wumiisyo wa Utaati	-Sand dams -Sand dams -Sand dams
3.Government ministries	-National Drought Management Authority	-National Drought Management Authority	-Sand dams

Technologies taken up by households in the study area included sand dams, rain water harvesting, shallow wells, water reuse and irrigation. The commonest technology adopted in both Kilili sub-location and Kyanguli sub-location was sand dams (71%) (SD=4.5), followed by rain water harvesting (40%) (SD=27.5), water reuse (39%) and the least was adoption of shallow wells (22%). In Kilili the most adopted technology was sand dams (76%) while the least was shallow wells (5%). In Kyanguli sand dams and rain water harvesting led (67%) while the least was shallow wells (39%) (Table 4.7).

Table 4.11 Technologies brought by the institutions in selected sites (%)

Technologies brought by the institutions	Sub-locations		Mean	SD
	Kilili	Kyanguli		
1. Sand dams	76	67	71	4.5
2. Rain water harvesting	12	67	40	27.5
3. Shallow wells	5	39	22	17
4. Water reuse	24	55	39	15.5
5. Irrigation	0	0	0	0

The study revealed that sand dam (72%) and rain water harvesting (97%) were commonly adopted in Kyanguli compared to Kilili (8% and 14%, respectively) Water re-use (54%) and irrigation (27%) were highly adopted in Kilili compared to Kyanguli (42% and 3%, respectively) re-use and (3%) irrigation (Table 4.11).

Table 4.12 Technologies adopted in selected sites (%)

Technologies adopted	Sub-locations		Mean	SD
	Kilili	Kyanguli		
1. Sand dam	8	72	40	45.3
2. Rain water harvesting	14	97	55.5	58.7
3. Shallow wells	11	39	25	19.8
4. Re-use	54	42	48	8.5
5. Irrigation	27	3	15	17

The main constrain for adaptation measures was lack of capital at both study sides, Kyanguli (100%) and Kilili (86%) (SD 9.9). Lack of information was the least reason for not adopting

with Kyanguli (39%) and Kilili (14%) (SD 17.7). Shortage of labour was only featured in Kyanguli (76%)

Table 4.13 Reasons for not adopting the technologies in selected sites (%)

Reasons for not adopting	Sub-locations		Mean	SD
	Kilili	Kyanguli		
1.Lack of capital	86	100	93	9.9
2.Lack of information	14	39	26.5	17.7
3.Shortage of labour	0	76	38	0

CHAPTER FIVE: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Water sources and water access in the selected sites

The study established that majority of households sampled were male headed compared to female headed households. This reveals that decision on water use is most probably dominated by men in the study area. Occupations of household heads most probably played a key role towards water use in agricultural practices as most individuals were farmers. According to the survey highest household size range within 4-6 people, this could be attributed to small land ownership by majority of household heads. The popular building materials were iron-sheets for roofing and bricks for walls. This could mostly be due to occupation since majority of the persons were either farmers or business men.

Results obtained on water sources revealed that rivers, shallow wells, boreholes, sand dams and roof catchment were the major sources of water in both study sites. Syolwe river, Kiome, Kwa Syonduu and Yoa were the only rivers in Kilili sub-location. In Kyanguli there were only two rivers i.e. Thange and Muliluni rivers in Kyanguli which were identified as the major source of water in the study area. There were more rivers in Kilili than Kyanguli most probably due to the presence of water catchment zone in Nzau hills which neighbours Kilili. It was noted that shallow wells dominated as the second option source of water mostly in Kilili which could be highly contributed to availability of water catchment from Nzau hill and boreholes commonly in Kyanguli was the third option across the study sites. This is most probably due to few seasonal rivers in Kyanguli. This observation was in agreement with Mutai and Ochola (2011) who noted that rivers are the main sources of water as long as weather remains favorable. It was clear that the major source of water in Kyanguli was shallow wells. This can be attributed to high water tables in this study sites, especially along

river banks where sand is commonly trapped by riverine vegetation during rain season. The least used water source in the selected sites was roof harvesting. This is due to perennial water shortages, the local communities have picked up the practice of roof catchments and have started the installation of water storage tanks to harvest rain water (MCIDP 2013-2017).

Water constitutes a vital element of household food security for humans and livestock. During drought, human beings have to walk long distances for poor quality water, their food security and standard of livelihoods is compromised and the quality of their livelihoods is lowered. During long trips to fetch water, substantial time is lost that can otherwise be used in other income generating and livelihood activities (Ngigi, 2009). It was evident from this study that majority of the households had to travel between 1-3 km to get water in both the sub-locations. This can be attributed to scarce water resources in the study area. In Kilili, majority of the households accessed water in less than one kilometre. This is most probably due to its location at the foot of Nzau hills and presence of many seasonal rivers and high water table. Overall, Kyanguli residents travelled a long distance to search for water which is mostly attributed to few seasonal rivers and low water table in the area (MCIDP 2013).

During when livestock have to walk for long distances from their regular dry season pasture and water sources, they lose body weight and weaken thereby fetching lower prices, or they become emaciated and die (Behnke and Muthami, 2011). It was clear that there was change in distance for water access mostly affecting Kyanguli which could be attributed to lack of permanent sources of water such as bore-holes and springs as they mostly depended on seasonal rivers. This observation agrees with Mutai and Ochola, (2011) who found that seasonal streams and sandy-river beds which are only available as long as the weather remains favourable. The increase in distance led to high cost of fetching water. Increasing number of

rural poor recognising access to water for food production livestock and domestic purposes as more critical than accessing to primary health care and education (UN 2003).

Five major water access problems were revealed in the study area. These included increased distance, high cost of water, dirty water, water scarcity and conflict with neighbouring communities. Increased distance, dirty water and high cost of water was highly recorded in Kyanguli which is likely to be attributed to low water table in this area. Kilibi recorded the highest scarcity of water and conflict on water with neighbours which is most probably due to high agricultural practices and high population in the area.

Overall water scarcity was highly recorded in both study sites followed by dirty water. This phenomenon is likely to be contributed by degradation of both surface and ground water resources through over-abstraction and illegal abstraction, among other factors thus leading to serious degradation of the water resources in terms of quantity and quality (MCIDP, 2013). In addition, many water sources in the dry-lands consist of open pools of stagnant water or open shallow well on sand, which in most cases are easily accessed. Further, in most communal water sources there are no water access control measures and in most cases water hygiene is compromised. For example, some of the people fetching water can use the same water source for bathing, washing and watering their livestock. These scenarios may explain why many respondents at Kyanguli cited dirty water as a problem-related to water accessibility. High cost of water in the study sites was most probably caused by the water access problems commonly water scarcity, dirty water and increasing distance to water sources. This is because many residents cited that they found it easier to buy water from water vendors rather than spending most of their time looking for water. The effect of water scarcity and increasing distance to water sources on water cost was most felt at Kyanguli which led in the

number of residents who reported that water access was costly. In the semi-arid regions, increasing numbers of the rural poor are recognizing access to water for food production, livestock and domestic purposes as more critical than access to primary health care and education (Anyandike, 2009). In semi-arid regions, increasing numbers of the rural poor are coming to see entitlement and access to water for food production, livestock and domestic purposes as more critical than access to primary health care and education (UN-WATER, 2003)

5.2 The existing water use coping mechanisms

In many cases, adaptation activities are local, district, regional or national issues rather than international (Paavola and Adger, 2005). Water use coping mechanisms included use of water harvesting structures, soil conservation techniques, water reuse, reduced number of livestock, diversification of crop types and varieties which were highly recorded in Kyanguli, irrigation and reduced water usage which was mostly practiced in Kilili.

Results obtained on water use coping mechanisms in the study sites revealed that soil conservation led in the water use coping mechanisms across the two sub-locations. Soil conservation measures such terrace making and tree planting are cost effective and this could be the reason why the two were dominant across the study sites. Crop diversification was the least water coping mechanism adopted in the study sites. This could be attributed to small land sizes among households and less awareness on the water use coping mechanism. Adoption of integrated watershed management in India has contributed to resilience of agricultural production and water security despite the high incidences of drought (Cooper *et al.*, 2006).

At Kyanguli, implementation of soil conservation schemes was the leading coping mechanism while the least was irrigation. Irrigation was less practised at Kyanguli most probably due less awareness and water scarcity due to the presence of few seasonal rivers. At Kilili, the major water coping mechanism was reduced water usage; most probably Kilili residents were more aware on water use coping mechanisms; this phenomena was mostly attributed to presence of agricultural extension services noted in the study site. Though irrigation was practiced in both study sites, it was most probably brought by the local community initiative due to experience in coping with water scarcity. In many cases, irrigated agriculture has been a major engine for economic growth and poverty reduction (IPCC, 2013). Kyanguli have been using these technologies mostly for more than five years compared to Kilili which could highly be caused by presence of many NGOs which was introduced earlier as the area was a settlement scheme with few water sources.

5.3 Institutions influencing water use coping mechanisms and uptake in the selected sites

In the study areas, there were five categories of institutions which influenced coping mechanisms and uptake of adaptation measures. These included non-governmental organizations, community based organizations, government ministries, individuals and private sector. NGOs like Utooni, African Sand Dam and Germany Agro Action and World Vision, Government Ministry and Private sector were common in Kyanguli mostly due to its locality being as settlement scheme thus attracting most of these institutions; while CBOs were commonest in Kilili. Particularly, institutions influenced water scarcity coping mechanisms and uptake of adaptation measures, and the commonest included the Non-Governmental Organizations (NGOs); since they are usually more widespread and more vibrant in undertaking their activities. Moreover, they involve communities actively in their projects and this may probably explain why NGOs were the major institutions that influenced water

scarcity coping mechanisms in the study area. Germany Agro-Action (GAA), World Vision and African Sand Dam (ASD) were the most common in Kyanguli while African Sand Dam was the mostly found in Kilili. Community based Organizations were the second most institutions that influenced water scarcity coping mechanisms in the study area. If well managed, CBOs create a sense of ownership of projects by the local citizens hence ensure sustainability of projects undertaken. This may probably explain why they have influenced water scarcity coping mechanisms in the study sites. The least institutions that influenced water scarcity coping mechanisms were Government ministries particularly ministry of agriculture and National Drought Management Authority (NDMA). Either through their own experiences or with technical assistance from development agents especially local NGOs and development partners, rural communities adopted a variety of innovative rainwater harvesting management technologies to cope up with recurrent droughts (Mati *et al.*, 2008a and 2008b, Ngigi *et al.*, 2008).

Technologies taken up by households in the selected sites included sand dams, rain water harvesting, shallow wells, water reuse and irrigation. Sand dams were common in Kilili while all others were common in Kyanguli. This can be attributed to low water table, high temperatures, low altitudes and level of awareness in the area. Utooni African sand dam facilitated construction of sand dams in both study sites, Germany Agro Action majorly contributed to roof catchment and community based organization, Wumiisyo wa Utaati contributed to terraces and sand dam construction. Sand dams, Zai pits, drip irrigation and roof and run off catchment were facilitated by world vision in Kyanguli. These institutions availed technologies within the study sites which were then adopted by the households. The commonest technology adopted in both Kilili and Kyanguli sub-locations was sand dams which might have been influenced by availability of seasonal rivers and presence of Non-

governmental organisations and Community Based Organisations in the study sites. The least adopted was shallow wells in both study sites most probably due to few rivers in Kyanguli and many boreholes and rivers in Kilili. According to Mutai and Ochola (2011), the main sources of water are perennial rivers, shallow wells and bore holes, which are only available as long as the weather remains favorable. Kyanguli had the highest adoption of the technologies compared to Kilili as noted in the study areas most likely due to high presence of NGOs in the region which brought about construction of sand dams, roof and runoff water harvesting and zai pits.

The study showed that Kyanguli highly adopted sand dam and rain water harvesting which could be attributed to presence of NGOs which advocated for the two technologies and also presence of iron sheet roof tops. Other factor could be presence of seasonal rivers which are favourable for construction of sand dam. Community in Kilili had low water harvesting and sand dam technology adoption this is most probably attributed to un-favourable rivers which are narrow and have no sand depositions. Water re-use and irrigation was highly adopted in Kilili this could be attributed to presence of bore-holes and majority had high education level and were famers. This is in agreement with Ngigi *et al.*, (2008) who noted that in semi-arid and arid areas where rainfall is low and predicted to decline further, in situ moisture conservation either through conservation agriculture or construction of rainwater control and management structures and rainwater storage in farm ponds, water pans, sand/sub-surface dams, earth dams, tanks for supplemental irrigation are gaining prominence.

The adaptations measures constrain were highly featured in Kyanguli this could most probably be due to over dependence on farming where it has highly been affected by water scarcity. This is in agreement with Behnke and Muthami, (2011) who noted that when

livestock walk for long distances from their regular dry season pasture and water sources, they lose body weight and weaken thereby fetching lower prices or they become emaciated and die.

5.4 Conclusions

- Rivers were identified as the major source of water in the selected study sites.
- Overall most households in both sites accessed water within 1-3km away from their homes.
- The commonest water access problem in the selected sites was water scarcity.
- The majority of the households in the study area had adopted soil conservation techniques as the major water use coping strategy.
- NGOs were found to have the greatest influence in the uptake of water scarcity coping strategies.

5.5 Recommendations

- This study recommends the increase of sand dams, rain harvesting technologies and more awareness on water scarcity coping mechanisms in the selected study sites to enhance water resources, access and availability in the study area.
- It also recommends studies to be carried out on the effects of water quality on human health in the study sites (Kilili and Kyanguli).

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**APPENDIX 1: QUESTIONNAIRE SURVEY FOR THE INHABITANTS OF THE
MAKUENI COUNTY**

Water access challenges and coping strategies in selected sites of Makueni County, Kenya, the purpose of this questionnaire is to assess rural community adaptation to water scarcity impacts and factor influencing the uptake of the coping mechanism. The information provided will be used solely for academic purposes and would be treated as confidential. Thank you for your cooperation. Please tick or fill in where appropriate

MODULE A: HOUSEHOLD IDENTIFICATION:

A1. Date of interview	Day:	Month:	Year:
A2. Name and gender of household head	Name:		Gender:
A3. Name of respondent/relation with h/head	Name:	Relation:	Gender:
A4. Name of sub-location			
A5. Questionnaire no.			

MODULE B: HOUSEHOLD GENERAL INFORMATION

B1. Age of Household Head Husband:_____Wife:_____

B2. Level of education of household head _____

B3. Occupation of Household head _____

B4. Marital Status 1. Single 2. Married 3. Divorced 4.Widow/er

B5. Household size _____

B6. Land ownership (size in acres)_____

B7. House Roofing Type: 1. Thatched 2. Iron-sheets 3. Tiles

B8. House Wall Type: 1. Mud 2. Wooden 3. Brick 4. Stones

MODULE C: WATER AVAILABILITY AND ACCESSIBILITY

C1. What significant changes in weather have you observed in your community over the last 20 years?

- 1. Unpredictable rains []
- 2. Prolonged drought []
- 3. Very hot seasons []
- 4. Very wet seasons []

Others (specify).....

C2. What is the main impact of these changes on the local community?

- 1. Crop failure []
- 2. Reduced water sources []
- 3. Flooding []
- 4. Human disease outbreaks []
- 5. Livestock disease outbreak Famine []

6. Others (specify).....

C3. If you have ticked reduced water sources above what are the main sources of water for domestic use?

- 1. Rivers []
- 2. Shallow wells []
- 3. Borehole []
- 4. Sand dams []
- 5. Roof catchment

6. Others (specify).....

C4. How far is your nearest water source?

- 1. Less than 1 km []
- 2. 1 – 3 km []
- 3. 4 – 5 km []
- 4. Over 5 km []

C5. Has the distance changed?

- 1. [Yes]
- 2. [No]

C6. If yes what are the impact?

1. Increased distances []
2. High cost of water []
3. Quality and quantity []

C7. What problems do you experience in accessing water?

1. Dirty water []
2. Scarcity of water []
3. Conflict with neighbouring communities []
4. If any other specify.....

MODULE D: EXISTING COPING AND ADAPTATION STRATEGIES USED BY RURAL COMMUNITIES ON WATER USE AND MANAGEMENT

D1. Have you made any adjustment in your own home practices to water scarcity?

1. Yes []
2. No []

D2. What adjustments have you made to address this water scarcity?

1. Build water harvesting schemes []
2. Implement soil conservation schemes []
3. Diversification of crop types and varieties []
4. Irrigation []
5. Reuse []
6. Reduce number of livestock []
7. Reduced usage []
8. Others (specify).....

D3. For how long have you been using the above measures?

1. 0-1 years []
2. 2-3 years []
3. 4-5 []
4. more than 5 years []

MODULE E: INSTITUTIONS INFLUENCING, COPING MECHANISMS AND UPTAKE OF ADAPTATION MEASURES BY THE RURAL COMMUNITY

E1. Are there institutions/organisations your community has worked with to address the effects of climate change on water use?

- 1. Yes [] 2. No []

E2. If, yes please indicate which type of institutions/organisations are they?

- 1. NGOs []
- 2. CBOs []
- 3. Government ministry []
- 4. Private sector []
- 5. An individual []
- 6. Others (specify.....)

E3. From the above rank the most influencing institution in the community

- 1. 4.
- 2. 5.
- 3. 6.

E4. What technologies the institutions brought?

- 1. Sand dams 2. Rain water harvesting 3. shallow wells 4. Reuse 5. Irrigation

E5. What have you adopted?

- 1. Sand dams 2. rain water harvesting 3. Shallow wells 4. Reuse 5. Irrigation

E6. List the main constraints to adaptation measures (Why not adopted)

- 1. Lack of capital []

- 2. Lack of information []
- 3. Shortage of labour[]
- 4. Others (specify).....

E7. Any water policy in place related to water use and management in the community

- 1. Yes []
- 2. No []

THANK YOU