UNIVERSITY OF NAIROBI

IMPACT OF CLIMATE EXTREMES ON WATER QUALITY AND SUPPLY IN URBAN INFORMAL SETTLEMENTS IN KENYA: A CASE STUDY OF KISUMU CITY

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DECLARATION

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DEDICATION

I dedicate this work to the following special people in my life: My father, Enock Masimbe, who always wishes me a brighter future through education. I am here now. Your spirit of education will always inspire the coming generation. You are my inspiration! My mother, Lydia Masimbe, who always believes in me and encourages me to live by my father's wishes. I managed to complete this work through their moral support. I thank you it is a blessing to have you both as my parents.

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ABSTRACT

The urban poor living in Kisumu City informal settlements are at particularly high risk from the impacts of climate extremes such drought, flooding and related water-borne diseases, in large part due to where they live, poor housing, and a poor waste management system. Access to water is obtained mainly through communal stand pipes, individual connections, tanks, or boreholes, rivers and springs. The risk of water contamination is high because of closely sited pit latrines, and is exacerbated by frequent flooding. The main objective of the research was to work with the communities to develop effective disaster risk reduction and climate change adaptation strategies to reduce the vulnerability of urban informal settlement dwellers to climate extremes that impact on their safe water supply. The data collection methods used included 333 household questionnaires analysed with SPSS software, identification and quantification of vulnerability, three focus group discussions with between 15 participants each, nine key informant interviews with local leaders, NGOs and government institutions, and time series analysis of climate trends from 1987- 2016. Results show an increasing trend of rainfall over Kisumu City. The trend also shows inter-annual variability of rainfall which showed increased or decreased patterns which resulted in drought and flooding. Majority (90%) of the respondents acknowledged that both flooding and drought impacted clean water supply, quality and use and 61% have to use alternative sources of water. The temperature trend over the same period showed the minimum temperatures rising faster than maximum temperature, which indicates warming. Majority of the respondents (83%) reported that flooding greatly impacted clean water supply because of pipe bursts which contaminated the water. Above half (62%) of the respondents also reported drought as a driver of water resource conflict especially among women who used water more frequently during dry-spells for household use. The respondents (62%) reported typhoid as the dominant health problem during dry-spells since they have to access to unsafe well water that had microbial contamination because of poor onsite sanitation. Almost all the respondents (97%) mentioned malaria as the most common disease related to flooding. The outcome of the study shows high vulnerability of Kisumu urban informal settlement dwellers to climate induced hazards such as drought and flooding which are accompanied by climate induced disease epidemics. The results show serious deficit in clean water supply and sanitation systems which pose some serious challenges like water contamination, poor solid waste management and contagious diseases. Climate extremes continue to pose severe impacts on water supply, rainfall and temperature as the projections still remain uncertain, and there is an urgent need for sound adaptation strategies to sustain water supply. There is need to invest in critical climate resilient water supply infrastructure. The county government needs to monitor climate change; rainfall, water utilities and water resources. An integrated water resource management should be in place which consists of various stakeholders.

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ACRONYMS

ACPC	African Climate Policy Centre
AIDS	Acquired Immunodeficiency Syndrome
ASAL	Arid and Semi-Arid Lands
AVOID	Avoiding Dangerous Climate Change Programme
BBC	British Broadcasting Cooperation
CBD	Central Business District
CCA	Climate Change Adaptation
DRR	Disaster Risk Reduction
EMCA	Environmental Management Co-ordination Act
ENSO	El Niño- Southern Oscillation
GCM	Global Circulation Model
HIV	Human Immunodeficiency Virus
IPCC	Intergovernmental Panel on Climate Change
KEWI	Kenya Water Institute
KIWASCO	Kisumu Water and Sewerage Company Limited
KMD	Kenya Meteorological Department
KPLC	Kenya Power Lighting Company
KUAP	Kisumu Urban Apostolate Programmes
LASDAP	Local Authority Service Delivery Action Plan
NGOs	Non-Governmental Organizations
SANA	Sustainable Aid in Africa International
SDG	Sustainable Development Goal
WRA	Water Resources Authority

URTI	Upper Respiratory tract infection
UN-HABITAT	United Nations Human Settlement Programme
UNISDR	United Nations International Strategy for Disaster Risk Reduction
UNESCO	United Nations Educational Scientific and Cultural Organisation
WHO	World Health Organization
WWAP	World Water Assessment Programme

CHAPTER 1: INTRODUCTION

1.1 Background

Kisumu, a port city, is the third largest city in Kenya, with an estimated population of 409,928 in the urban centre (KNBS & SID, 2013). It has a number of informal settlements, including Manyatta, Obunga, Otonglo and Nyalenda (Figure 1.1). Informal settlements are housing areas where the residents have no legal ownership with regards to the land or dwellings they inhabit. Informal settlements lack formal supply of basic infrastructure and services, public space and green areas, and are constantly exposed to eviction, disease and violence (World Bank, 2008). The housing usually does not comply with planning and building regulations, and they are often situated in geographically and environmentally risky areas (UN-HABITAT, 2003). According to UN-HABITAT, informal settlements can be a form of real estate speculation for all income levels of urban residents, affluent and poor. Informal settlements are the most deprived and excluded form of settlements which are depicted by poverty and frail housing often located in the riskiest urban areas.

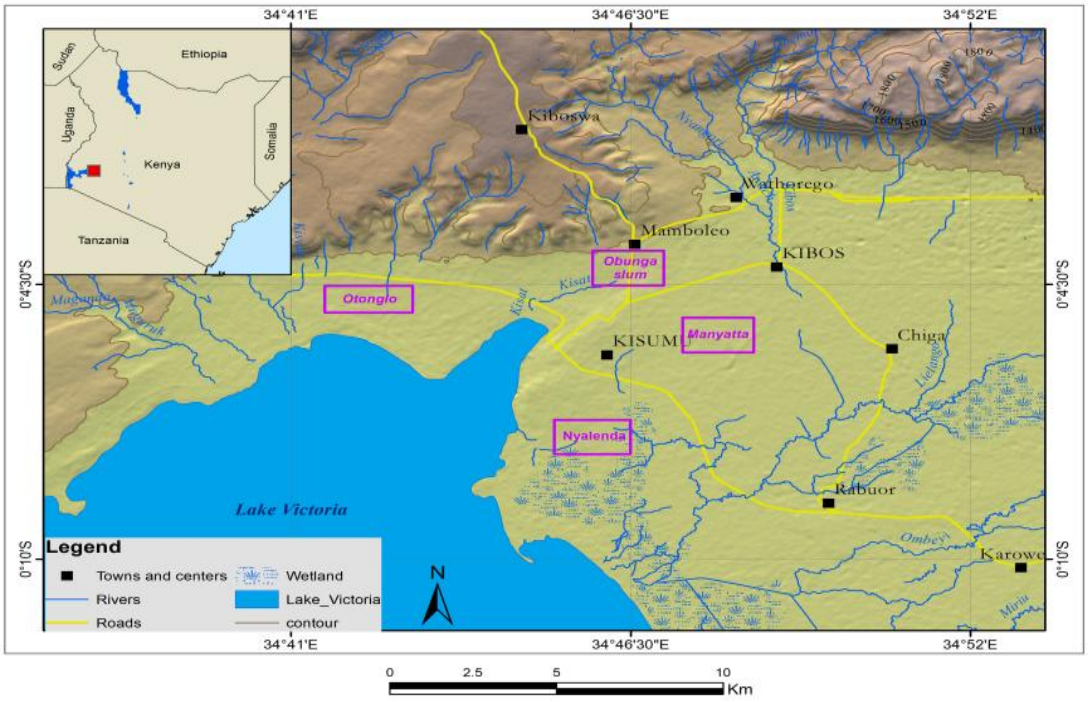

Figure 1.1 Location Map of Kisumu city urban informal settlements (Manyatta, Obunga, Otonglo & Nyalenda)

1.2 Problem Statement

Kisumu's informal settlements residents are mostly, low income earners, with the bulk of them generating income from small businesses. The unplanned temperament of the settlements, infrastructure and services remains key challenges for residents. Provision of safe water to the poor is a priority internationally (WHO-UNICEF, 2013). Access to water is mainly through communal stand pipes, which supply over 65% of the population (Practical Action, 2013). A small percentage gets access to water through individual household connections, boreholes or tanks. There is an elevated risk of water contamination from poorly sited pit latrines, and it is worsened by frequent flooding; pit latrines get flooded during heavy rains and then the surface runoff carries the overflow down towards the Lake Victoria basin, contaminating wells and the environment. This is why Kisumu slum dwellers experience high occurrence of waterborne diseases such as typhoid and dysentery. There are a number of accessible water points in all the settlements, but the residents often face difficulties with the quality and quantity of the water in the accessible water points.

Climate change has been evident in the Lake Victoria Basin. King'uyu et al. (2000) determined a decrease of minimum temperatures near larger lakes like Lake Victoria and coastal areas. They analysed the relationship between climatic patterns (air surface temperature and precipitation) and water resources over the Lake Victoria basin and found out that there is a daytime warming near the coastal areas and lakes, but the most alarming pattern of temperature variations was the recurrence of the extremes. The recurrences were also associated with below normal rainfall and El Niño–Southern Oscillation (ENSO). The "*inter-annual variability of rainfall for the region is dominated by recurrences of above 10 to 11 years, 5 to 6 years, 3.5 and 2.3 years' spectral peaks"* (Nicholson, 1996). A case of extreme climate variability occurred in 1961 when Lake Victoria inundated the surrounding land in Kisumu city due to continuous heavy downpour. The 1961 incident was closely related to Indian Ocean surface temperatures and Indian Ocean dipole (Conway, 2002). A similar incident occurred in 1998 which was related to El Niño–Southern Oscillation (ENSO) (Olago et al., 2007); the Kisumu City residents were wading through flood water because the swollen Lake Victoria basin turned dry land into swamps in May 1998 (Lukalloand & Okello, 1998). The extremely dry years in the city include 1984, 2001 and 2002 related to La

Niña (Indeje et al., 2000). The changing climate may affect the transmission of malaria, which is endemic in the area, and which can disproportionately affect vulnerable populations in the informal settlements without adaptive capacity (Martens et al., 1999). Research done by Wandiga et al. (2010) also analysed past climate trends and health records from 1961-2001 in the East Africa highlands, and they found a link between climate variability and increased malaria epidemics. A number of factors account for different climate-induced epidemics and these range from land use change, resistance of drugs and poverty levels, to climate change (Lepers et al., 1988) and use of poor quality water which contributes to diarrhoea and infant mortality (Bartram and Cairncross, 2010).

Drought and flooding has greatly affected the Kisumu residents. According to the Disaster Profile of Kenya in 2002 about150,000 people were affected, in 1982 floods have severely affected 4000 people and dating back to 1985 about 10000 people have been affected by flooding. According to the Star Newspaper recently in May 2018 stated about 15 people were found dead in Kisumu City due to flooding (Reuters, 2018).

Government and organizations working in Kisumu slums and other institutions have not been able to successfully implement new and appropriate adaptation measures to stop the growth of informal settlements and their vulnerability to climate change and its impacts. The need to build resilience and adaptive capacity to climate change is rapidly becoming a core concern facing urban informal settlements in Kenya and elsewhere, and is particularly important in a context of rapid urbanization, inadequate infrastructure, and limited financial and technical capacity of governments (Dodman et al. 2017). This is because climate change increases existing structural causes of poverty, inequality and poor health.

1.3 Research Questions

This study sought to address a number of research questions namely:

2. How have climatic conditions (temperature and rainfall) in Kisumu area varied overtime?
3. What are the types of flood or drought impacts dominant in Kisumu City informal settlements?
4. What are the main sources and uses of water in Kisumu City informal settlements?

5. What is the current level of vulnerability in the informal settlements in Kisumu City?
6. What adaptation measures exist in the Kisumu City informal settlement or in the county?

6.1 Aim and Objectives

Aim and Overall Objective

The main aim of the study was to develop effective community disaster risk reduction and climate change adaptation strategies to reduce vulnerability of urban informal settlement dwellers to climate extremes that impact on safe water supply.

Specific Objectives

1) To evaluate the impacts of climate extremes on water supply, quality and use in Kisumu City informal settlements
2) To determine the vulnerability of Kisumu City slum dwellers to the impacts of climate change related extreme events
3) To assess the coping and adaptive capacity of the informal settlement dwellers to risks posed by climate change impacts on water resources
4) To develop, with the participation of the affected communities, a framework for adaptation and disaster risk reduction to mitigate adverse climate impacts on water quality and supply in Kisumu City informal settlements.

6.2 Justification and Significance of the Research

1.5.1 Justification

It is important to determine climate extremes impacts on water supply, quality and use in Kisumu City. According to the WHO, fresh water supply in the whole world is limited and the urban poor have water deficiencies. Globally, 40% of the urban poor are affected by water scarcity which is expected to increase as a result of global warming. Adequate safe water supply is recognized as a human basic need. However, the number of people without access to safe water supply has been increasing in Africa because of rapid urbanization particularly in peri-urban and slum areas (WHO, 1996). Clean water supplies have been decreasing and this has been a challenge impacting the whole African continent (UNDP, nd). About two thirds of the world population living in urban areas by 2050 are expected to face

water challenges, and the demand of water is expected to increase by 55% since 2015 (Reuters, 2015). An estimated one third of the world deaths in the less economically developed countries is caused by consumption of contaminated water, followed by an increase in water-related diseases, which are exacerbated by climate extremes (WHO, 1997).

Characterizing the vulnerability of Kisumu slum dwellers to the impact of climate change related extreme events is crucial in order to find the entry points for disaster risk reduction and adaptation for climate change. According to the Sendai framework, it is crucial to understand disaster risk in the light of prevailing vulnerability, adaptive capacity and exposure of the slum residents with their assets, the environment, and hazard characteristics. This understanding can be used for preparedness and response, risk assessments, prevention and mitigation of disaster risk (UNISDR, 2015).

Examining the coping and adaptive capacity of the informal settlement dwellers to risks posed by climate change impacts on water resources is crucial because both adaptive and coping capacities are important elements of vulnerability and with men, women and youth at the research site. Three hundred and thirty-three household questionnaires were administered to individual men, women and youths in the villages available during the time of the research. Interviews with key informants were made with government officials, non-governmental organisations representatives, local leadership and other relevant people. Eight key informants were interviewed including representatives from Sustainable Aid in Africa (SANA) International, Kisumu Water and Sewerage Company (KIWASCO), Ministry of Environment and Forestry and Ministry of Water and Sanitation. A transect walk was made in the study area and observation were done on settlement patterns, measurements of the distance between the houses and vulnerability of houses along rivers to flooding.

CHAPTER 2: LITERATURE REVIEW

This chapter presents an overview of what is known in the Kisumu urban informal settlements in relation to the impacts of climate extremes on water supply quality and use. The chapter also unveils the most prominent climate hazards in the urban informal settlements including climate induced disease. Adaptive and coping capacities in the urban informal settlements have also been captured and explained.

2.1 Impacts of climate extremes on water supply, quality and use

The impacts of climate extremes such as drought and flooding are first felt on water supply quality and use. These climate extremes can disrupt water supplies and sanitation facilities leaving contaminated water and putting millions of lives at risk (UNICEF, 2016). When people lack clean water, people are at risk of diseases such as diarrhoea. Most of the regions in the world at risk of droughts and floods have low levels of access to water and sanitation, and the populations living in these areas are extremely vulnerable (UNICEF, 2016). However, to tackle the issue of climate change there is need for further research on how to increase access to sustainable water sources and improve sanitation to cope with a changing climate. The impact of climate change has indicated itself through more frequent droughts and higher average temperatures which result in high water stress, and also through an increase in the frequency of floods, which have a great impact on the urban water supply and sanitation sector (World Bank, 2013).

Climate change is expected to impact the hydrological cycle and rainfall patterns across Africa which will put pressure on water availability, demand and accessibility, which has great influence on economic development. In the African continent, the water sector is very sensitive to climate variability and change. Climate change is expected to hamper operations of water and sanitation infrastructure and services (WHO, nd). Current population patterns and trends of water use show that countries in "*Africa will exceed the limits of their economically usable, land-based water resources before 2025*." (UNECA 2013). However, the impact of climate change on water resources across the continent will be felt in different ways. In some parts, it will increase water and in others it will reduce it. One major challenge in the water sector in Africa is limited access to safe ground and surface water. There is

insufficient infrastructure to provide sufficient and reliable water supplies for drinking, farming and other uses, and limited governance capacity (UNECA, 2013).

Urbanization is growing rapidly in Africa; the percentage of people living in the urban areas is expected to grow from 36% in 2010 to 50% in the year 2030 (World Bank, 2015). According to UN-HABITAT, "*Over 25% of the world's 100 fastest-growing cities are now in Africa and this rapid growth raises concerns over water security. Water security concerns partly arise as utilities responsible for piped water and sewerage struggle to keep pace with population growth and demand for such services"*. However, the informal settlement inhabitants rely on water vendors who sell water, or from illegal water pipe connections, both of which are not adequate (Gronwall et al., 2010). The impact of climate change is expected to have an enormous impact on freshwater bodies including the amount of water and the flow of rivers which will, in turn affect the slum dwellers (Palmer et al. 2008).

Unplanned urban development has been taking place because of an increase in urban population. Under such circumstances, pit latrines, uncollected waste and other environmental pollution hazards are widespread and most likely contaminate ground water sources. Initially, residential sites were constructed at a distance from such hazards. The contamination of well water is linked to inadequate well protection and well lining which might be an entry point for sewage in the underlying underground water sources from surrounding pit latrines (ARGOSS, 2001). In Kisumu, shallow wells are the main source of water supply for domestic purposes in the low income urban areas (Cronin et al., 2007) because they are cheap, easy to maintain and are the most convenient way to get water (Water Aid, 2013), These wells are often at risk of high contamination because of infiltrating surface runoff that is pollutant-laden.

2.1.1 Documented impacts of climate extremes on urban water resources, supply, quality and use

In 1998, the Kisumu city residents were wading through flood water because of the swollen Lake Victoria basin which turned dry land into swamps in May 1998as water of Lake Victoria inundated the surrounding land because of continuous and uncharacteristically large amounts of rainfall. The first time the water rose was in 1961; it was the first-time extensive

flooding was noted and the water level in Lake Victoria never returned to its original level. The rising level of the lake had drastic impacts on lakeside ports and cultivated areas which had an impact on food security.

Following heavy rains in 2009 in Kisumu City, a number of incidences were reported of people drowning in Nyamasaria River, Auji River and Kibos River (Daily Nation, 2009). All the rivers in Kisumu city were overflowing because of the heavy rains which flooded the houses. People with businesses made losses because of the extreme amounts of rainfall. The heavy rains left some inhabitants homeless and property destroyed. Primary school students had to do their lessons outside because their classrooms were destroyed in the storm (Daily Nation, 2009).

2.2 Vulnerability of slum dwellers to extreme climate events

The existing literature encompasses a lot of definitions, concepts and methods to contextualize vulnerability. "*Vulnerability is the propensity or predisposition to be adversely affected"* (IPCC, 2012). "*It is a dynamic concept, varying across temporal and spatial scales and depends on economic, social, geographic, demographic, cultural, institutional, governance and environmental factors."* (FAO/OECD, 2012). The United National Development Programme, on the other hand, describes vulnerability as "*A human condition or process resulting from physical, social, economic and environmental factors, which determine the likelihood and scale of damage from the impact of a given hazard*" (UNDP, 2004).

Kisumu informal settlements, like any other informal settlement in Kenya, face: "*The incidence of crime, robbery and gang violence, as well as gender based domestic violence…which undermine both macro and micro economic growth and productivity of a country's development, as well as social and individual well-being*" (UN-HABITAT, 2007). The key challenges faced by the informal settlement dwellers are lack of access to clean water, good housing, solid waste management, proper health care, improved sanitation, security and energy (UN-HABITAT, 2007).

Urban vulnerability in low-income settlements is influenced by location. Few low-income settlements are well planned and well located (Satterthwaite et al. 2007). The pro-poor populations tend to live in slums or informal settlements, where the houses are self-built and sub-standard. The settlements lack adequate water, drainage and basic facilities, and are situated in risk-prone areas (World Bank, 2010). About one billion of the population in the world lived in these conditions in the year 2010 and the figure was then expected to rise by 1.4 billion by the year 2020 (WDR, 2010).

Africa's urban informal settlement dwellers are specifically vulnerable to the negative health effects of global climate change and rapid urbanization (WHO, 2009). There is need for further research to understand the impacts of climate change on the health in the urban informal settlements, in order to come up with context-specific and appropriate adaptation strategies. Public health interventions in Africa must put in consideration the relationship between urbanization and climate change and their impact on health on pro-poor urban populations (WHO, nd).

2.2.1 Vulnerability to climate-related diseases

The effects of climate change will be progressively felt in the African region. Climate change and urbanization will cause more unpredictable events and disease burden (IPCC, 2007). The analysis of climate data for precipitation and temperatures show that cholera epidemics are related to El- Niño years and are triggered by unusually warm and wet seasons, and surveys showed that the affected communities are highly vulnerable (Olago et al., 2007).

Most of the urban inhabitants in Kisumu are poor and relying on either small business incomes or self-employment. Only 8% in the urban informal settlements had a source of income from formal employment (Olago et al., 2007). Monthly incomes of the urban poor are quite low. Poverty increases risk and susceptibility to diseases such as cholera and malaria because they lack funds to access medical facilities. Further, the health care systems that exist in the lake basin areas cannot cope with climate-induced diseases such as cholera, thus rendering the communities vulnerable to the impact of climate variability and change.

A link between climate variability and malaria epidemics was reported in the highland of Lake Victoria Basin (Wandiga et al., 2009). Further, the study noted that poverty level and the socio-economic status of the communities were coupled to climate variability and malaria epidemics. The study confirmed that the vulnerability of the communities' health to climate change is dependent on the coping and adaptive capacities of the community. The socio-economic status also revealed how the communities are vulnerable to malaria epidemics because of limited health facilities (Wandiga et al., 2009).

2.2.2 Vulnerability to urban flooding

Cities in Africa will experience more severe and frequent flooding. "*Floods are the most reoccurring, widespread, disastrous and frequent natural hazards of the world."* (Aloysius, 2012). *"Flooding accounts for approximately one third of all natural disasters in the world."* (UNISDR, 2012). According to World Disasters Report in 2014, floods account for almost 50% of the deaths from climate related hazards. Over the past year's, flooding patterns have been shifting and becoming less predictable for the Kisumu city inhabitants, and poverty has led more people to stay in areas vulnerable to flooding (Terumoto, 2006). Following continuous heavy downpour of rainfall in several parts in Kenya, there have been bursts and over flow of pipes, drainage/surface water channels reported in various parts.

Western Kenya region has had several incidences of flash floods and destructive rain storms that have caused destruction of property, as well as loss of life and livelihoods to the residents of the region especially in Kisumu urban informal settlements. In Kenya, floods are the most common hydro-meteorological disaster. Most of the flooding in Kenya has been a result of global warming according to BBC in 2007, which is depicted by extreme hydro-meteorological events, which will increase incidence climate variability and change. Kenya stands at 6.2% according to the natural disaster risk index (Kenya Disaster and Risk Profile, 2014).The Disaster Risk Index calculates the number of death risk caused by natural disasters within a country according to EU (2017). It is calculated by multiplying the hazard and the vulnerability divided by the capacity (Bagawdi & Mukheriji, 2017), a country is therefore indexed according to the level of its exposure and degree of risk. An index of 6.2% shows high risk to climate induced disasters and the potential of how the urban informal settlement dwellers can be affected.

Following a flood disaster in Kisumu City, poor populations often have no other option than to build sub-standard housing and resettle in high-risk areas. Most residential houses in Kisumu City are not permanent (iron roofs and mud walls), accounting for 54.7% which does not reflect an urban infrastructure corresponding with the city status. The material used to build the non-permanent houses makes them more vulnerable to floods.

A study shows that water drawer's in Kisumu have declining reliability of piped water supply in the urban areas and an increasing population in the urban (Thompson et al., 2001) and peri-urban areas, that are not connected to the municipal water pipes (Okottoet al., 2015). Deep wells have potential to supply water in Kisumu though the development cost is relatively high, affordable only to the rich, while the urban poor have to wait for donor projects to construct those wells for them. The urban poor can only afford to dig shallow wells which, in terms of public health, are highly susceptible to contamination, hence posing a high risk of disease to the urban poor population that uses them.

2.2.3 Vulnerability to urban drought

Urban droughts are characterized by lack of access to water supplies for drinking and sanitation, and for agricultural production. Climate change is expected to exert prolonged and more frequent drought in Africa, and water scarcity will increase in urban areas in Africa over the next century (IPCC, 2007). The droughts may trigger rural to urban migration, thereby stressing urban infrastructure. Droughts may also lead to crop failure and increase strain on local food markets, thus resulting in increased rates of malnutrition among urban informal settlement inhabitants.

The incidence of drought has become prominent in Kisumu city informal settlements. Drought has resulted in severe water shortages in most parts of western Kenya and its effects manifest in the form of reduced pasture for livestock, increased human/livestock deaths, disease outbreaks such as cholera and typhoid, increased school drop-outs, poor crop production, and limited access to basic food which has led to malnutrition (UN-OCHA, 2009). Urban drought and water shortage which have become worldwide problems which seriously affect the social and economic development of cities (Jin et al., nd). Water shortage has threatened human lives and the development of Kisumu city. The gap between water

demand and water supply is increasing. According to the (World Bank, 2007), the demand for water is increasing because of population growth, increasing and competing demands from agriculture and industry, declining water quality and climate change.

2.3 Coping and adaptive capacity of informal settlement dwellers

"*Adaptive capacity is the capacity of a system to adapt in order to be less vulnerable, is a dynamic notion. It is shaped by the interaction of environmental, social, cultural, political and economic forces that determine vulnerability through exposures and sensitivities, and the way the system's components are internally reacting to shocks."* (FAO/OEDC, 2012). Two dimensions exist in adaptive capacity, coping ability and adaptive capacity to change (Smit and Wandel, 2006).

Coping among the slum dwellers happens on different scales; individually, communally or institutionally. Individual coping strategies apply at the level of an individual's activities within the household. Coping at communal level to improve resilience is more effective and normally requires a community based organization to mobilize the communities. The county government may operate as a driver of institutional coping strategies though the communities do not know much about them. Coping strategies entail different activities and make use of social networks and livelihood diversification. Most crucial coping strategies employed in African cities entail a lot of modifications to the built and physical environment (Wamsler, 2013). However, the coping strategies in Kisumu city urban informal settlements are similar to Nairobi slum residents which are based on an individual scale with uncoordinated efforts which are not effective since they do not involve the community as a whole especially relating to flood and drought impacts (MnU, 2016). To cope with flooding the residents normally apply the following strategies: stack sand bags with rocks on doors to prevent water entering their homes; dig large trenches as floodwater outlets; build gabions and rock barriers to hold flood water; use small plastic containers to drain water from houses, and; elevate their housing structures above the ground (MnU, 2016).

How the urban informal communities respond (by either adapting or becoming vulnerable) to climate induced disease epidemics, flooding or drought is determined by their socio-economic status, institutions and governance structures and civil organizations, the public

health structures, and the level of awareness of climate induced crisis. Together with other factors such as low income levels and food insecurity, such communities might be unable to adapt to climate variability and projected climate change impacts. However, there have been community efforts and measures employed at the household level in the urban informal settlements which include washing hands before eating, water treatment for drinking water, digging pit latrines, digging trenches for flood water outlets, building gabions for flood protection, and establishment of community water points and water storage tanks in times of dry seasons.

2.4 Adaptation and disaster risk reduction strategies for sustainable and safe water supplies

Adaptation is considered to be the adjustment of a natural or human systems in response toactual or expected climatic stimuli or their effects, which moderates harm or exploit s beneficial opportunities (IPCC, 2007). Adaptation looks at the whole disaster cycle from pre-disaster planning to post-disaster reconstruction (DFID, 2010). On the other hand, *disaster risk reduction is the concept and practise of reducing disaster risks through analysis and management of their causal factors. It reduces exposure to hazards, lessens the vulnerability of people and assets, and improves management of the land and environment and preparedness for adverse events* (UNISDR, 2009). There is need for more coupled adaptation and disaster risk reduction strategies because of an increase in frequency and intensity of weather and climate hazards, since climate change and disasters have the most impact at local level especially in pro-poor communities (UNISDR Asia and Pacific, 2012). Tonga is one of the leading countries which has managed to incorporate Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) into their development plans with government agencies working closely together (UNISDR, nd).

Cities like Cape Town in 2016/2017 faced serious water challenges because of prolonged drought. A “Day zero” scenario, where taps run dry and people queue for water, was anticipated in Cape Town in August 2018 and was projected to likely stretch up until 2019 (Reuters, 2018). The water manager’s measures to adapt to the water shortage and avert the impending crisis included limiting water consumption to 23 gallons per day per household which equates to 87litres (Nace, 2018). Households coping strategies to the water shortage

included no washing of cars, cutting time of showering, no watering of lawns and flushing toilets when necessary (Wong, 2018). In the 2005 drought in South Africa, the local authorities increased water tariffs to promote efficient use of water; other measures taken were restriction of water, reuse of grey water, consumer education and installation of technology systems such as low flow systems (Mukheibir and Ziervogel, 2007).In 2018 Cape Town is now considering desalinisation of water, rainwater harvesting and relocation of people and water storage as adaptation measures to water shortage scenario (SANBI, 2014). In Quito in 2009, based on a prediction of reduction in water supply due to climatic changes, the local government introduced a range of adaptation plans including water rationing and mechanisms to reduce water conflict (Hardoy and Pandiella, 2009).

Most of the cities in the less developed countries still have large deficits in piped water, drainage and sewer systems and also have very low investment capacities in regard to water management (Revi et al., 2014). Nearly a billion people in the world live in the urban informal settlements where water and sanitation providers are not willing to invest or are restricted by law (Mitlin and Satterthwaite, 2013). Research has shown that adapting to urban water shortage and sanitation systems needs significant investments (Arnell, 2009). In Africa, it is suggested that close to USD$ 1 – 2.7 billion is required annually in sub-Saharan cities to adapt current water infrastructure and another 2.6 billion to adapt new developments which include water storage and waste water treatment (Muller, 2007). Most urban water systems are dependent on reliable electricity supply especially for pumping and water treatment. Wandiege Water and Sanitation Company, which is one of the biggest water supplier in Manyatta informal settlements, has frequently experienced power blackouts, making water supply very limited. During drought periods people have to resort to alternative sources (Foeken et al., 2013).

The two main sources of water in Kisumu City are Kibos River and Lake Victoria. To adapt to water scarcity that resulted from a prolonged drought in 2016, the Kisumu Water and Sewerage Company (KIWASCO) rationed water in parts of Kisumu city. The areas affected included Mamboleo market, Nyamasaria, Otonglo and Kanyamedha. The most affected areas were mostly those served by Kajulu plant whose water levels had reduced by 67% (Chepkoech, 2017). Whereas areas where the lake supplies water were not heavily affected,

those that relied on Kibos water supply were urged to cut back their water use. KIWASCO put in place mechanisms to manage the low supply and urged the residents to equip themselves with adequate water storage capacity. KIWASCO issued some water saving tips so that their customers could adapt, including: checking all faucets, pipes and toilets for leaks; installing water-saving showerheads and low-flush toilets; taking short showers, and; rinsing vegetables in dishes instead of running water. The dry spell also affected other western Kenya counties including Homa Bay, Siaya, and Kakamega, with several families staring at starvation (Chepkoech, 2017). The shortage forced Kisumu residents to travel for long distances in search of water as major rivers such as Nyando, Kuja, Awach and Miriu also begun to dry up because of the drought.

Most of the urban informal settlement residents in times of water scarcity have to look for alternative water sources. In Manyatta area they are forced to use Nyamasaria river water, which is very dirty and contaminated or water from KIWSCO pipeline which is a very long distance away for the residents in the area. In other informal settlements like Katuoro and Obunga, the alternative sources are natural springs, shallow wells and boreholes (Foeken et al., 2013). To adapt or cope with water shortage, about 66% of residents in the urban informal settlements in Wandiege and Katuoro reduce water use and recycle, 20%do not cope or use an alternative, and 11% buy water storage tanks (Foeken et al., 2013).

The Kenya government's revised Water Act 2016 gave provision for establishment of a National Rainwater Harvesting and Storage Authority to mitigate the issue of water scarcity in the country. The Act establishes a variety of players in the water sector, including water service boards and water supply companies and also aims to reduce pressure on water sources and enhance water supply security. To adapt to water challenges in the Kisumu informal settlements, Practical Action and Kisumu Urban Apostolate Programmes (KUAP) in (2008-2013) through "People's Plans into Practice" project tried to improve water access in the urban informal settlements in Kisumu. The project worked with communities to find alternative access to water and sanitation. The interventions included safe access to surface and ground water (wells, boreholes and springs), and some of the interventions included extension of pipes in such a manner that water kiosks and individuals could be connected.

Another intervention the project facilitated was a negotiated to reduction in the price of bulk water supply from kshs37 to kshs25 per cubic meter (Philip and Stevens, 2013).

In terms of DRR, Kisumu City local authorities have not applied disaster risk reduction strategies for sustainable water supply to cope with a changing climate. According to the Hyogo Framework pilot project for Making Cities Resilient in 2013-2014, Kisumu city local government staff has medium level expertise with very limited skilled staff on disaster risk reduction and climate adaptation. The pilot project also revealed that: the local government allocation of financial resources for DRR activities is minimal; the local revenue indirectly deals with DRR issues; local authority support is still minimal, and; risk assessments are not updated regularly. The pilot project for making cities resilient also showed that policies exist though implementation is a major challenge. Disaster risk assessments are still not incorporated in the development planning process. The local government of Kisumu still has not invested or maintained critical water infrastructure to reduce risk and to cope with a changing climate, neither has it conducted awareness or educational programmes for local communities on DRR. The educational curriculum also has minimal courses or training on climate risk (UNISDR, nd). Further, the results of the pilot project conducted by UNISDR in (2013-2014) shows that private sector, civil society and citizens do not participate in sustainable management of ecosystems and not much has been done in this regard because people are said to be ignorant. A communication strategy for early warning does not exist; therefore, the communities are caught unaware. The Red Cross has always provided emergency supplies and shelter and evacuation routes, but the local authority has never been involved, though the local government has sensitised the urban poor on local hazard trends, early warning and risk reduction measures (UNISDR, nd).

CHAPTER 3: STUDY AREA AND METHODS

3.1 Study Area

3.1.1Location and Description

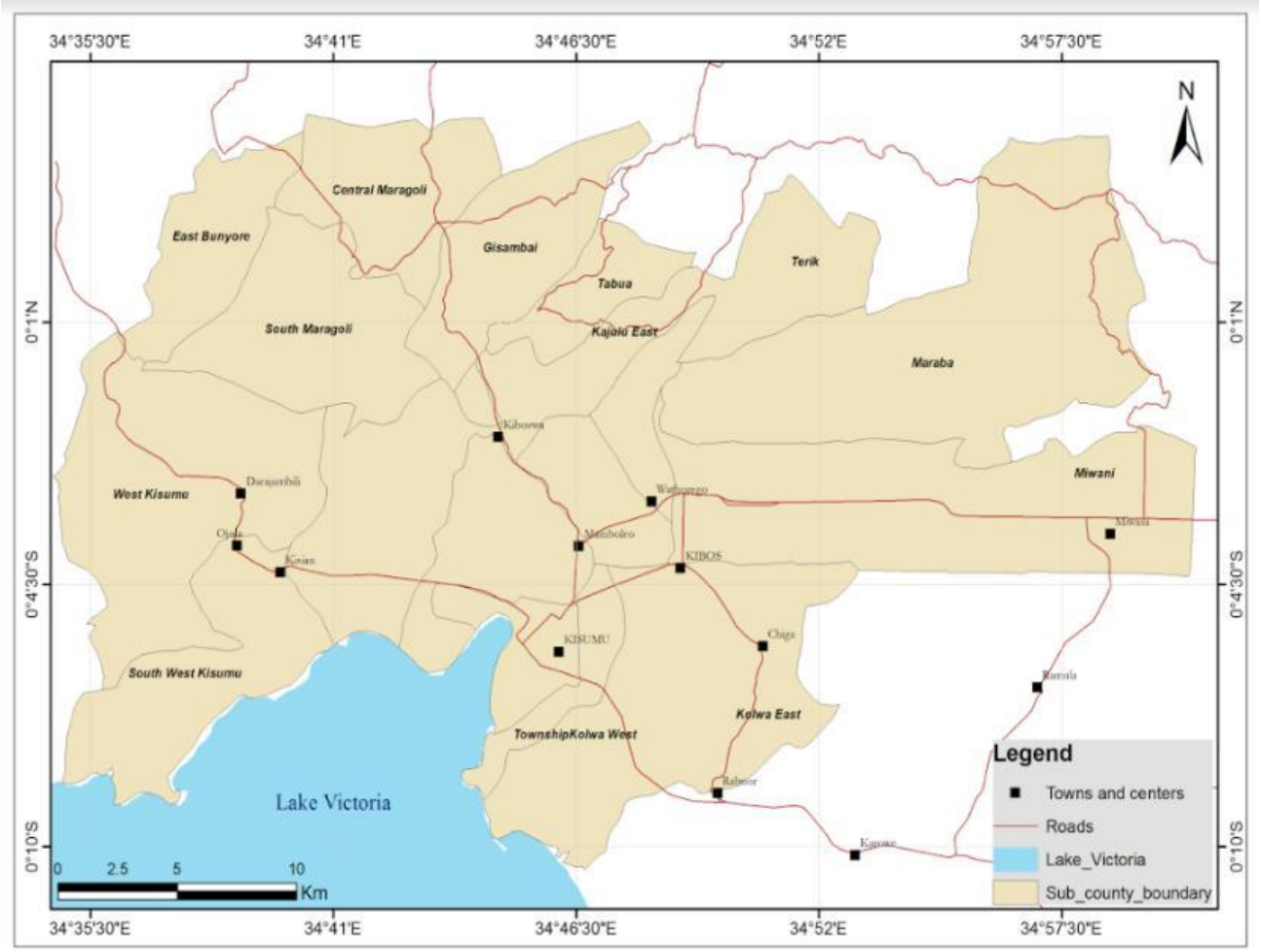

Figure 3.1: Kisumu Informal settlements location and administrative boundaries

3.1.2 Biophysical Setting

3.1.2.1 Climate

The climate is tropical in Kisumu. The climate here is as classified by the Köppen-Geiger system (Critchfield, 1983). The system categories are based on the monthly and annual average of precipitation and temperature. Kisumu has a significant amount of rainfall during the year. It has two wet and relatively warm seasons in March, April, and May (MAM) and October, November, and December (OND)and two dry seasons in January and February (JF)

(hot and dry) and June, July, and August (JJA) (cold and dry). Some parts of Kisumu County, including Kisumu city, have a third subdued rainfall peak in August (Nicholson, 1996; Lugaria, 2016). The short rains average about 600mm and long rains average about 1200mm annually (GOK, 2014). Kisumu city's average annual maximum temperature ranges from25^{o}C to 35^{o}C and the annual minimum range is 9^{o}C to 18^{o}C (GOK, 2014).

3.1.2.2 Vegetation

Kisumu City is characterized by woodland vegetation and the main type is Savannah woodland which includes *Butyrospermum, Acacia* and *Albizzia*. The main species of herbaceous vegetation are *Hyparrhenia*, *Londetia, Cyperus papyrus and Cymbopogon*. The main crops planted in Kisumu County are sugar cane, coffee, sorghum, maize, cotton, sisal, tobacco, beans millet, wheat and root crops. Application of fertilizer on the crop fields is light (Shimonaka, 1984). Kisumu City has no pronounced forest, so agro-forestry needs to be put in place to raise forest cover of the county for environmental conservation (GOK, 2013).

3.1.2.3 Land Use and Resources

The current land use in Kisumu City is residential, fish farming, sugar cane production and individual gardening and others include; electricity sub-stations, cemeteries, petroleum depots, warehouses and a railway line -most of these land uses are along rivers or the Lake Victoria (Javan, 2016). However, agriculture has not been a favourable livelihood because of low production due to recurrent droughts and floods and soils which do not drain water quickly. On this note low production in agriculture has been the force behind rural-urban migration which has also led to an increase of urban informal settlements within the city (UN-Habitat, 2005). Kisumu county population is mostly rural which depends on natural resources for day to day life and livelihoods. The city experiences population pressure and the land is overcrowded because it is sub-divided into very small sizes (GOK, 2013).

3.1.2.4 Physiographic and drainage

Kisumu city lies in large lowland near the tip of Winam Gulf. Kisumu County is divided into 3 zones which are the lowland on the floor of the Nyanza rift, the midland area in Maseno and the upland area comprising Nyabondo Plateau. The upland areas have elevations up to1, 835m (asl). Kano plain including the foot slopes of the surrounding hills descends from 1220m to 1135mcontours with east-north-east to west-south-west slope. Consequently, the

drainage flows in that direction except in the south where it discharges into the Miruka swamp (Costa & Ominde, 1973).

3.1.2.5 Water Resources

Most of Kisumu City water supply is drawn from Lake Victoria, and some from the upper reaches of River Kibos (Maoulidi, 2010). Other rivers are: Kajulu, Lidango, Mamboleo, Luanda, Nyamasaria and Kisian (see Figure 1). Kisumu City urban informal settlement residents mainly rely on ground and surface water which is accessible. The groundwater levels range from 2m-5m from the soil surface in the urban informal settlements (Ong 'or& Long-Cang, 2007). Shallow wells are frequently used because the KIWASCO water is very limited in the informal settlements (Okotto, 2015). The water from shallow wells provides the urban poor households with water for domestic purposes. This water is vulnerable to contamination by overflowing pit latrines and insufficient drainage in the area. Kisumu city is characterized by a large area of wetlands. People who reside around the wetlands are frequently affected by flooding. The city still remains with a clean water challenge, though it has the largest fresh water body in the world; this is because of high contamination of water sources due to flooding and poor sanitation systems (UN- HABITAT, 2015).

3.1.2.6 Biophysical Vulnerabilities

A number of urban informal settlements in Kisumu City are situated in areas that have experienced relatively frequent outbreaks of cholera that are more often related to floods than to poor hygiene (Olago et al., 2007). Most of the urban informal communities are in close proximity (0 to 20) km to the lakeshore (Olago et al., 2007). Those communities living along the lake shore are more likely to suffer from cholera than those living some distance away from the lake. Most lake shore communities are also vulnerable to malaria. The urban poor are unable to access medical treatment due to lack of finances and lack of proper health care facilities during malaria outbreak (Wandiga, 2006).

3.1.3 Socio-economic and political Setting

3.1.3.1 Political and administrative context

The city is divided into six administrative sub-locations which include: Korando, Kasule, Kalowa, Kisumu North, East and West, and South (Figure 3.1). The city's governing authority is the Kisumu County Authority. The Local Authorities Service Delivery Action

Plan (LASDAP) is a participatory approach which is being used in Kisumu City - it allows the Kisumu City residents to be involved in monitoring, evaluating and implementing development projects in the city to ensure that the local government delivers quality services. The Kisumu City residents are informed on local government reforms and form action groups to advocate for welfare in their communities (Agong et al. 2012).

3.1.3.2 Economic Setting

The Kisumu City economic sector is represented by sub-sectors of trade which include tourism, industrialization, and national heritage (GOK, 2013). The main sources of income for urban poor inhabitants include; income from employment in industrial plants, informal trade, agriculture and livestock and non-motorized transportation (*bodaboda*) (UN-Habitat, 2009). The potential for urban agriculture has been overlooked in terms of employment creation and provision of food to the urban poor. Kisumu City has one of the highest food poverty indexes in Kenya with most of the residents living below the food poverty line (UN-HABITAT, 2004). The strong presence of the private sector in Kisumu City might be an opportunity to create private and public partnerships to enhance socio-economic development (GOK, 2013).

3.1.3.3 Social Setting

Kisumu City in 2001was upgraded to city status and it has an estimated population of 500,000 people, with most of the population being under the age of 19 (Agong et al., 2012). It has a moderately developed urban infrastructure. Kisumu City is the core for trade, fish-farming, industries and communications in the lake basin. In Kenya, the city is ranked the poorest (of three cities) with 48% of its population living below the poverty line (UN-HABITAT, 2005). The urban development and environmental issues in the city include: poor housing and land use planning; high incidence of HIV/AIDS; lack of public awareness which reflects low literacy levels; poor waste management, and an insufficient and out-of-date water and sewerage system. Other environmental issues include the existence of hyacinth in Lake Victoria which clogs water intake pipes, insufficient energy supply; poor sanitation, pollution, unplanned human settlements and increasing crime rates. According to UN-HABITAT, Kisumu City has 24.6% literacy rate of urban poor who have reached secondary school level. The city schools have a low enrolment rate in primary schools and high gender equality between the boys and girls (UN-HABITAT, 2004-2009).

3.1.3.4 Health Setting

The health challenges in Kisumu City include: HIV/AIDS pandemic which is leaving a growing population of orphaned children without parents. Malaria is an endemic disease in this city and leads to high mortality and morbidity, especially in children during rainy season because of stagnant water which allows mosquitoes to breed (Agong et al., 2012). Other illnesses commonly reported include: Upper Respiratory Tract Infections (URTI) and water borne diseases like typhoid and cholera. Typhoid, cholera and diarrhoea are related to poor sanitation conditions and limited water supply, which are prevalent in informal settlements where pit latrines and shallow wells are within close proximity of each other. There is limited access to medical facilities because they live in unplanned settlements and therefore the urban informal settlement dwellers are forced to search for traditional medicine. The local authority of Kisumu City lacks an inclusive plan for dealing with climate-induced diseases (Agong et al., 2012).

3.1.3.5 Regulatory Framework

The Constitution of Kenya 2010 makes provision for county planning and development including issues on quality housing which are core aspects in the urban informal settlements for the urban poor. The Water Act 2016 and the Environment Management and Coordination Act and Physical Planning Act all have aspects that touch on local urban management. The Environment Management and Coordination Act (EMCA) 2015 is the main legal document guiding the management of natural and environment resources in Kenya. The Act has an effective framework for dealing with environmental risks and can be directed towards ensuring a safer environment for informal settlements residents. It highlights the *right to a clean and healthy environment to the citizens* (UN-Habitat, 2004-2009).

The Climate Change Act 2016 states that: *National and county governments should to formulate programmes and plans to enhance the resilience and adaptive capacity of human and ecological systems to the impacts of climate change*. This includes the urban poor who have no adaptive capacity as well as the protection of water resources. The Act also goes on to say that national and county governments should, *mainstream and reinforce climate change disaster risk reduction into strategies and actions of public and private entities*. This assists in building resilience of the county. Therefore, the act makes provisions for public awareness that, *"Public entities at each level of government shall, at all times when*

developing strategies, laws and policies relating to climate change, undertake public awareness and conduct public consultations. "This builds awareness in the county on matters regarding climate change and so that people are not caught unaware.

The Urban Areas and Cities Act, 2011 promotes community participation in the governance of urban areas and cities. The Public Health Act, states that, *"every person has a right to accessible and adequate housing, and to reasonable standards of sanitation*" and makes provisions for sanitation and housing which is key towards building urban resilience in Kisumu City informal settlements.

3.1.3.6 Socio-Economic Vulnerabilities

There is strong evidence of socio-economic vulnerabilities in Kisumu City because of the scale of urban poverty and inadequate nutrition levels. Most housing structures are constructed with iron roofs and mud walls, accounting for 54.7% of the residential buildings in the city (Wandiga, 2007). In addition, the city slum dwellers live below the poverty line, leading to an assortment of sustainability challenges such as lack of access to clean water, quality sanitation and drainage systems, basic facilities, health care, and security, as well as over-crowding and insecure tenure. An indication of social vulnerability is also seen by the number of people living in illegal settlements because they cannot afford to stay in lawful accommodation. Most of the city urban poor prefer to rent houses in informal settlements because they are affordable. Kisumu City water sources for the urban poor are mainly rivers and shallow wells that are vulnerable to pollution (Chung, 2011).Most poor urban households derive most or all of their income from work in the informal economy with low income levels and food insecurity (GOK, 2013); this is an indication of socio-economic vulnerability of Kisumu City informal settlement communities.

3.2 Conceptual Framework for the Research

This section presents a conceptual framework, which shows an overview of the research which shows climate vulnerability change and the factors involved to able to archive an urban resilient community in Kisumu informal settlements. Climate change and variability has increased flooding and drought in Kisumu City.

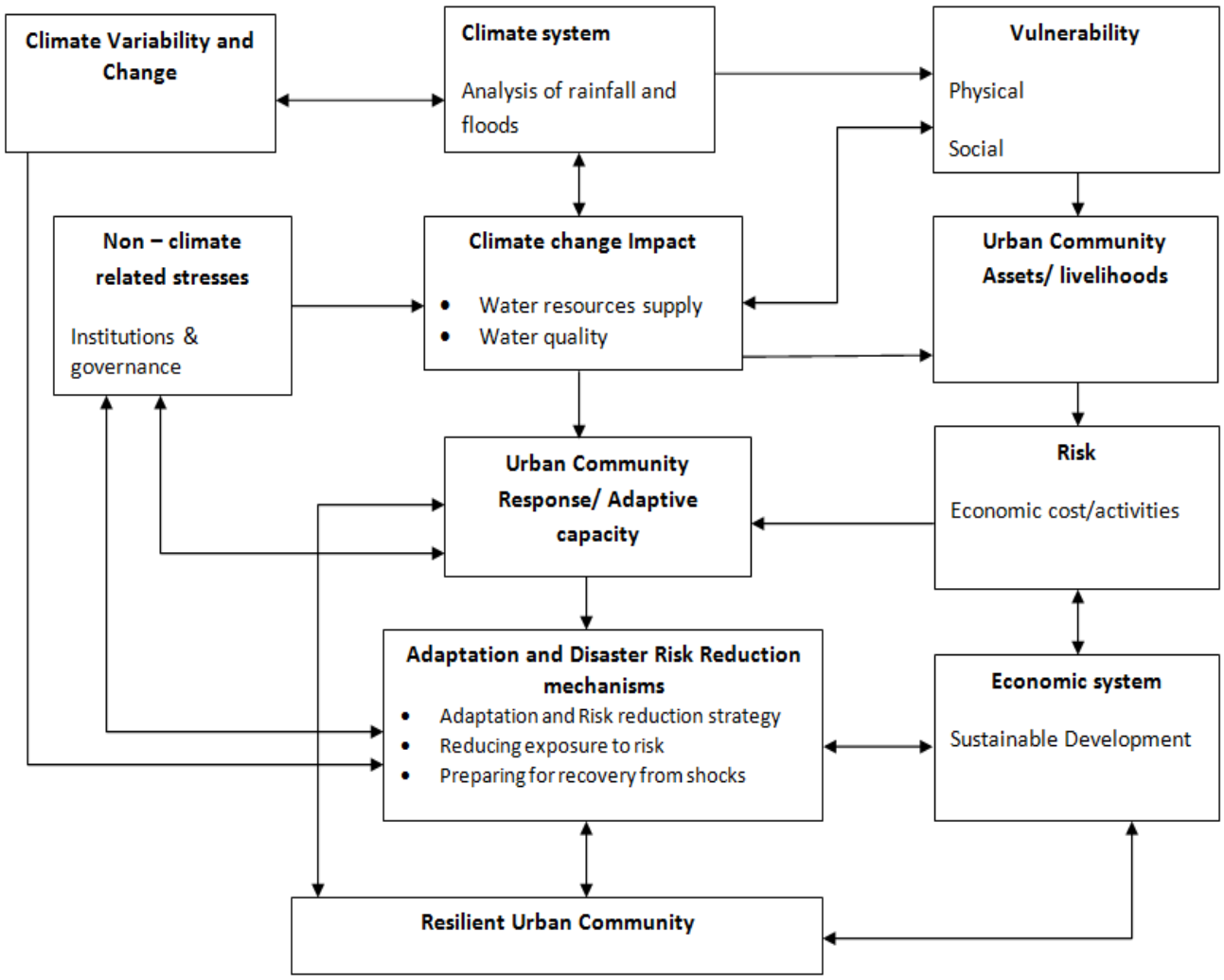

Figure 3.2: Conceptual Framework

The aim of the study was to provide strategies to build an urban resilient community in Kisumu City urban informal settlements to climate extremes. Climate change impacts on water supply and quality (Figure 3.2); however, the magnitude of the impact is also exacerbated by non-climatic stresses which include the institutions and the governance structures which exist in Kisumu City. Climate change impact has a negative impact on livelihoods which are dependent on water resources and urban community assets because they expose the communities to risk through, for example, damage to built infrastructure and natural assets, and disruption of critical public services and economic activity. Climate change impact has strong and adverse effects on the urban communities in informal settlement since their capacity to cope and adapt is low, and the existing governance and institutional structures have inadequate responses to the problem. Adaptation and disaster

risk reduction mechanisms are proposed to help build resilience of the urban informal settlement residents to the vagaries of climate change.

3.3 Methods

3.3.1 Introduction

Desktop studies were done from existing literature to identify knowledge gaps, and vulnerability factors. Climate data was collected from Kenya Meteorological Department (KMD). Water quality data was obtained from Water Resource Authority (WRA) and other databases. A household questionnaire was administered, and key informant interviews were conducted. Existing and relevant national and county policies and legislation were analysed to identify the strengths and weaknesses in the institutional and governance framework relating, in particular, to informal settlements. An observation check list was prepared to note down the status of housing structures, water supply and sanitation sources and surroundings. Focus group discussions were held to identify gaps in community adaptation.

6.3 Methods for Objective 1

3.3.2 Desktop studies

The literature accessed and studied included international journals, governments reports, international agency reports (e.g. UN-HABITAT&UNEP), and online magazines. Newspaper articles on flooding and drought in Kisumu City were accessed from the Nation Centre, Nairobi. Climate data from1986-2016for Kisumu Airport Station was obtained from the Kenya Meteorological Department and used to analyse annual and monthly rainfall and temperature trends.

3.3.3 Household Questionnaire Survey

A household questionnaire was administered from 23rdNovember to 12thDecember2016 with questions relating to water supply, quality and use (see appendix A). The questionnaire was pre-tested with about (15) households and was modified for the households to understand the terminology used in the questionnaire. About three hundred and thirty-three (333) households were selected based on their availability during the time the fieldwork was undertaken in the

informal settlements, to analyse the water use, supply and quality (see appendix A). The sample size of the household questionnaire was calculated using the Yamane (1967) formula:

Sample size $\mathbf{N} = \frac{N}{1} + \mathbf{N}\,\mathbf{(e)}^{\mathbf{2}}$

Where: n is the sample size, N is the population size, and e is the level of precision (0.5).

Eight (8) key informant interviews with local leaders, NGO representatives and village elders were done at the same time the household questionnaire was being administered.

3.3.4 Data Analysis

(a) Climate data

The trends in mean annual rainfall and temperature for the period 1986-2016 were established using time series analysis; for this purpose, MS Excel Data Analysis Toolkit was used. A t-test was also made using MS Excel data analysis tool kit to test the significance of each linear trend line established from the annual and monthly rainfall data. The annual mean rainfall data for each year was divided into two groups - from 1987-2001 and from 2002-2016 -to test the significance of the trend line using two sample t – test assuming unequal variances and using a p-value of 0.05. The same method was also used to test significance of the temperature data. To assess the climate variability of rainfall the coefficient of variation (CV) was calculated using a formula:

$$CV = \frac{Standard\ Deviation}{Mean} \times 100$$

To plot the rainfall and temperature anomalies to identify the climate extremes from1987-2016_ the following formula was used:

$$\frac{Annual\ avverage - Mean\ of\ annual\ average}{Standard\ Deviation}$$

(b) Household survey data

All the completed questionnaires were first checked for completeness and consistency. They were then numerically coded. The responses relating to the impact of drought and flooding

on water quality, supply use and adaptation measures were then entered into SPSS and analysed, calculating percentages of the responses and creating graphs and tables.

3.4 Method for Objective 2

3.4.1 Desktop studies

Climate data was collected as explained in section 3.4.1. Newspaper articles, journals on drought and flooding in Kisumu City were also collected as also explained in section 3.4.1. Literature was obtained from through government and international organization reports and other archives. Vulnerability indicators were identified from existing literature and classified into two groups – individual/household and environmental.

3.4.2 Household Survey Questionnaire

The household questionnaire (section 3.4.2) explored the characteristics of vulnerability (socio-economic and biophysical), and risks (flooding, drought, pollution and others) (see appendix A). A transect walk was taken and observations were made on the 23rd of November 2016 to note the distance between water sources and sanitation systems, the conditions of shelter structures, water and sanitation sources and conditions.

3.4.3 Data analysis

To analyse vulnerability of Kisumu City slum dwellers vulnerability indicators were identified and classified into "individual/household" and "environmental" classes (Table 3.2). Quantification of vulnerability indices was based on the following classification scale (1) - low vulnerability/low exposure; (2) Moderate vulnerability/exposure; (3) - high vulnerability/exposure (Table 3.1).

Table 3.1: Quantification of Vulnerability in Kisumu City

Vulnerability Indicators			
Individual/Household	Vulnerability index	Environmental	Vulnerability Index
Age and Gender	1-3	Sanitation and Drainage	1-3
Income	1-3	Water Supply	1-3
Energy, cooking & lighting	1-3	Biophysical Environment and location	1-3
Shelter Quality	1-3	Roads and Pathways	1-3
Level of Education	1-3	Population Health	1-3
Total Max	15	Total Max	15
Cumulative Vulnerability or Cumulative Exposure: LOW, 1-6; MODERATE, 6-12; HIGH, 12-18.			

Table 3.1: Vulnerability indicators in Kisumu City assessed in this study

Vulnerability Indicators	
Individual/Household	**Environmental**
Age and Gender	Sanitation and Drainage
Income	Water Supply
Energy, cooking & lighting	Biophysical Environment and location
Shelter Quality	Roads and Pathways
Level of Education	Population Health

3.6 Methods for Objective 3

3.6.1 Desktop Studies

3.6.2 Household Questionnaire Survey and Key Informant interviews

The household questionnaires (see section 3.4.2) were used to evaluate coping strategies, adaptive strategies, water sources and uses (including seasonal influences) (See appendix A). The purpose was to understand respondent's socio-economic profile including: their water sanitation and hygiene status; the community's perception of climate risk; the kind of strategies they use to cope with and adapt to the climate risk; the current institutional structures and the community's perceptions of what is required to build adaptive capacity. Interviews were held with key informants at the same time the household questionnaire was carried out (see section 3.4.2) and other key informant interviews were done from 2nd to 5th June 2017 to get additional information from the county government ministry of Water and Environment in Kisumu County, education and health sectors, NGOs and institutions like KIWASCO and SANA international, to understand existing coping strategies so as to develop effective adaptation and risk reduction measures (See Appendix B).

3.6.3 Data Analysis

Climate and hydrological data were analysed as outlined in section 3.4.3. Data collected from the household questionnaire on the status of coping strategies and the level of risk in the area and biophysical and socio-economic risk of the informal settlements was analysed using SPSS as mentioned in section 3.4.3.

3.7 Methods for Objective 4

3.7.1 Desktop Studies

Relevant national and county policies and plans as well as the Hyogo 2005 and Sendai 2015 Disaster Reduction frameworks were critically examined in relation to the findings of this research on existing governance arrangements, institutional and community capacities to mitigate and adapt to flood and drought risks under a changing climate. A disaster risk reduction framework incorporating adaptation strategies and actions to build a safer and resilient society in Kisumu informal settlements was developed.

3.7.2 Focus Group Discussions and Key Informant Interviews

Three (3) focus group discussions were done from 31st May to 2ndof June 2017 with the slum dwellers in order to determine the best adaptive strategies to build resilience. The focus group discussion were held in Nyalenda, Manyatta and Obunga informal settlements (see table 3.3). Each group gathered for the research, composed of between 15 and 20 participants randomly selected in the 3 different settlements. A set of questions was prepared regarding their sources of water, water-related problems during flooding and drought periods, how they deal with the challenges and what the communities recommend for sustainable water supply in their village (see appendix C).

Table 3.2: Focus Group Discussions held in the informal settlements

Name of Informal Settlement	Date	Group Composition		Total number of participants
		Male	Female	
Obunga	31/06/17	9	7	16
Manyatta	01/06/17	10	6	16
Nyalenda	02/06/17	10	5	15

Eight (8) key informant interviews with a focus on adaptation strategies were done with the village elders, institutions and government officials (see appendix B). A set of questions was also prepared similar to the questions in the focus group discussions. In addition to the questions were questions regarding strategies that have been put in place to manage climate extremes, what communities have done to deal with drought and flooding challenges and if they are any policies in place which deal with water supply and climate change.

3.7.3 Data Analysis

Qualitative data analysis for the household questionnaire for existing adaptation strategies and the socio-economic and biophysical conditions was done using SPSS (see section3.4.3). Quantitative household survey findings/responses are presented in tables and graphs. The triangulation method was used to verify the responses from the key informant interviews and the responses from the focus group discussions and household questionnaire responses to see if they were in consensus.

CHAPTER 4: IMPACTS OF CLIMATE EXTREMES ON WATER SUPPLY, QUALITY AND USE IN KISUMU SLUMS

4.1 Introduction

This chapter presents an overview of the results from the first objective. The household questionnaire was administered to the households in Nyalenda A and B; Manyatta A and B; Obunga and Otonglo urban informal settlements. The questionnaire covered a sample size of 333 households. The distribution of the respondents interviewed in each informal settlement is shown in figure 4.1. The distribution of the respondents was almost uniform in order to get balanced responses in each settlement and to be able to give comparisons.

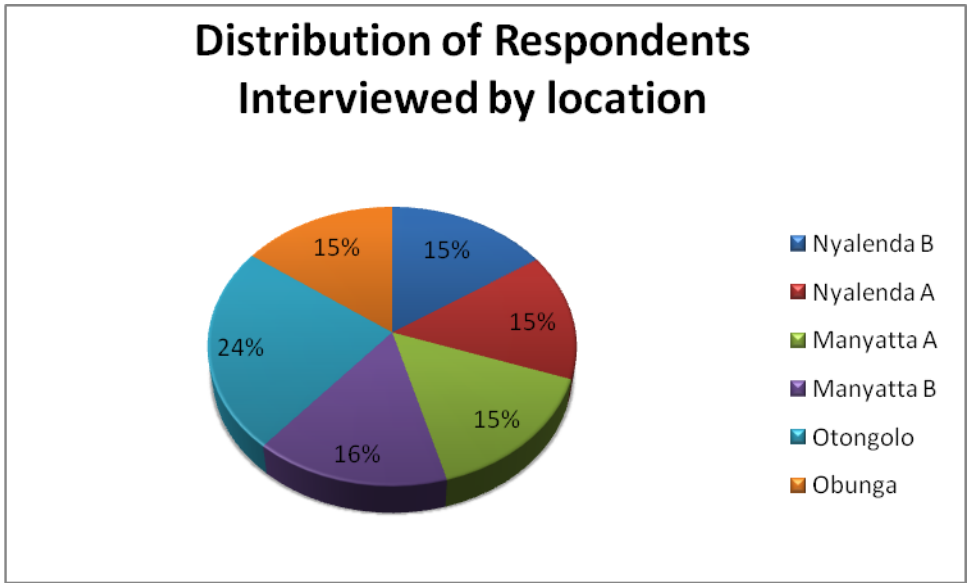

Figure 4.1: Distribution of the Respondents' interviewed in Kisumu City informal settlements

The respondent's views on the impact and of climate extremes on water supply, quality and use in the urban informal settlements in Kisumu City and the vulnerabilities are analysed in this section. Rainfall and temperature data that was analysed (see section 4.2) was used to validate the respondents' views. This chapter addresses issues relating to the water sources,

the main water supply system, water quality and use in the urban informal settlements and how they are impacted by rainfall and temperature changes.

4.2 Rainfall Trend Analysis

The climate of Kisumu city and environs (rainfall and temperatures) is described in section 3.1.2.1. The 30-year rainfall data for Kisumu Airport station (1987 to 2016) that was analysed shows an increasing trend (from 1350 mm to 1400 mm) which was not found to be statistically significant (Figure 4.2). A t- test was done to test the significance of the trend using a p-value of 0.05. The t- test results showed the increasing rainfall trend was not significant as the calculated t-value which is -0.30 is less than the t critical values tail one and two which means the trend is not significant (Table 4.1).

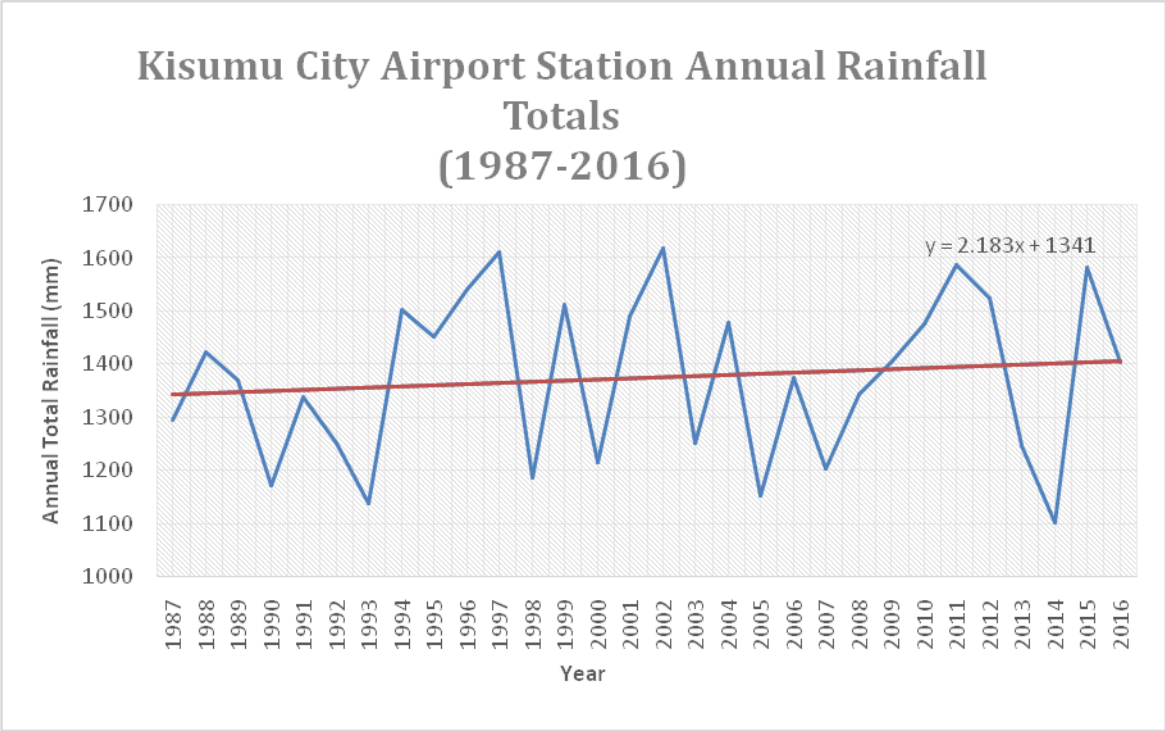

Figure 4.2: Annual Total Rainfall for Kisumu City Airport Station

Although the trend was not statistically significant the slight increase in rainfall is in agreement with IPCC 2007 which states that rainfall is also expected to increase significantly towards the end of the 21st century.

Table 3.1: t- Test for testing significance of the rainfall trend 1987-2016

t-Test: Two-Sample Assuming Unequal Variances

	Rainfall 1987-2001	*Rainfall 2002-2016*
Mean	1366.1	1383.586667
Variance	22878.4	27011.4
Observations	15	15
Hypothesized Mean Difference	0	
Df	28	
t Stat	-0.30321222	
P(T<=t) one-tail	0.381984813	
t Critical one-tail	1.701130934	
P(T<=t) two-tail	0.763969625	
t Critical two-tail	2.048407142	

The driest year over the 30-year period was 2014 with 1100 mm of rainfall, while the wettest year was 2002 with 1625 mm of rainfall (Figure 18). The rainfall trend shows inter-annual variability of rainfall (Figures 4.2), with a slightly declining trend in variability (Figure 4.5). The rainfall anomalies show 1993, 2005 and 2014 as the driest years and 1997, 2002, 2011 and 2015 as the wettest years. However, during the interviews with key informants' from WRA and SANA international there was an agreement that the rainfall seasons over the years are no longer predictable, and the drought periods last longer. The coefficient of variability over the years has been highest in years 1988.1995, 1997/1998/ 2005 and 2011 (Figure 4.3) which indicates high climatic risk.

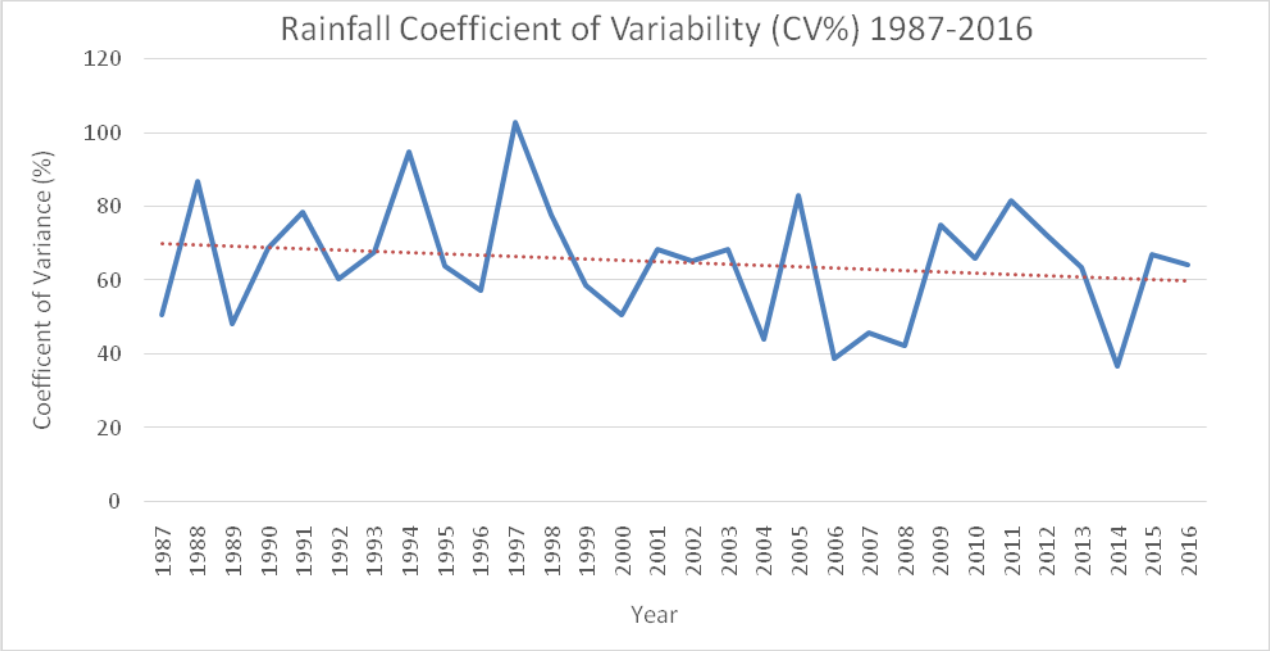

Figure 4.3: Coefficient of Variability of Rainfall 1987-2016

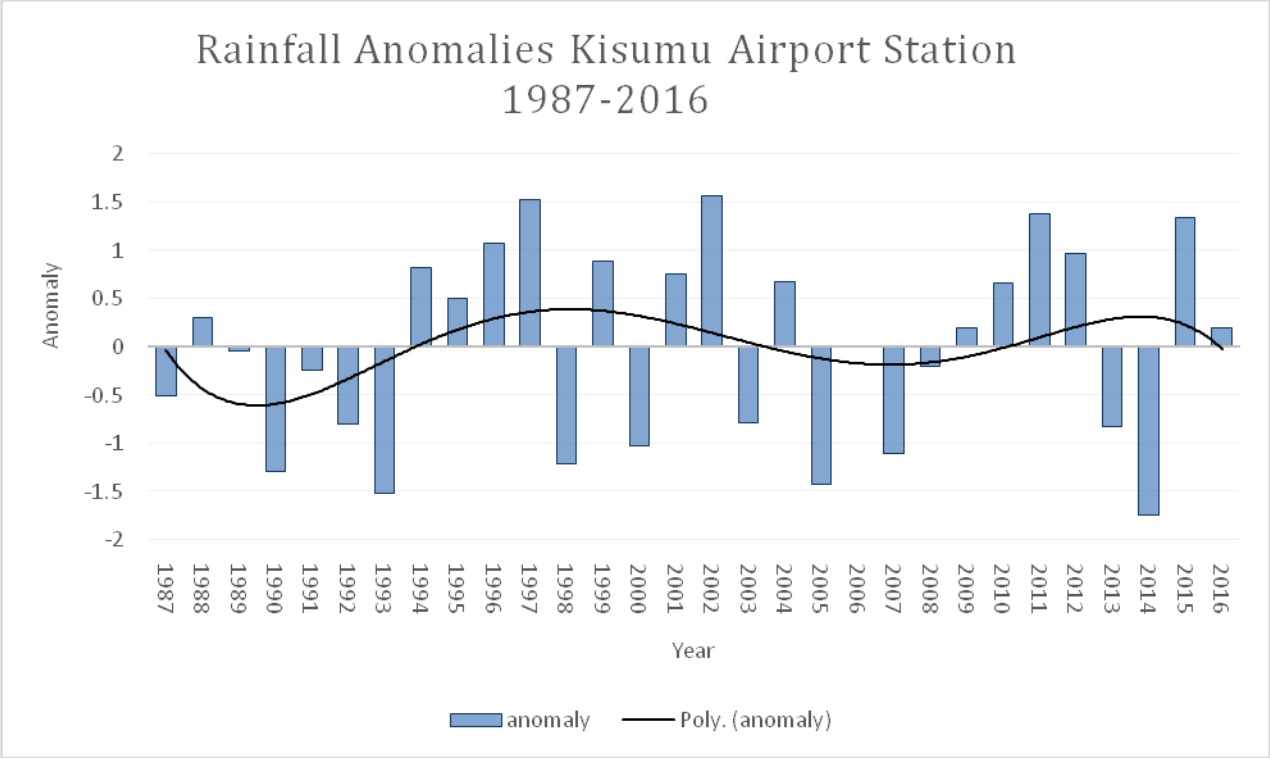

Figure 4.4: Rainfall anomalies at Kisumu City Airport Station 1987-2016

The rainfall trend over MAM season in the time series shows a combination of increased amounts of rainfall and large deficits in 2011 and 2014 which is an indication of drought and high risk to flooding (Figure 4.5). The OND season shows an increasing trend of rainfall which has a huge peak in 1997 (Figure 4.6). Ninety-six percent (96%) of the respondents stated that they experience flooding seasonally and close to 2% of the respondents say that the frequency of flooding has increased (Table 4.2). Seventy two percent (72%) of the respondents said that drought occurs seasonally though 22% of the respondents might think the drought periods are more frequent because they no longer see rain in the rain seasons, and they also mentioned that it is now difficult to predict rains because there is now a high uncertainty related to weather changes (Table 4.3).

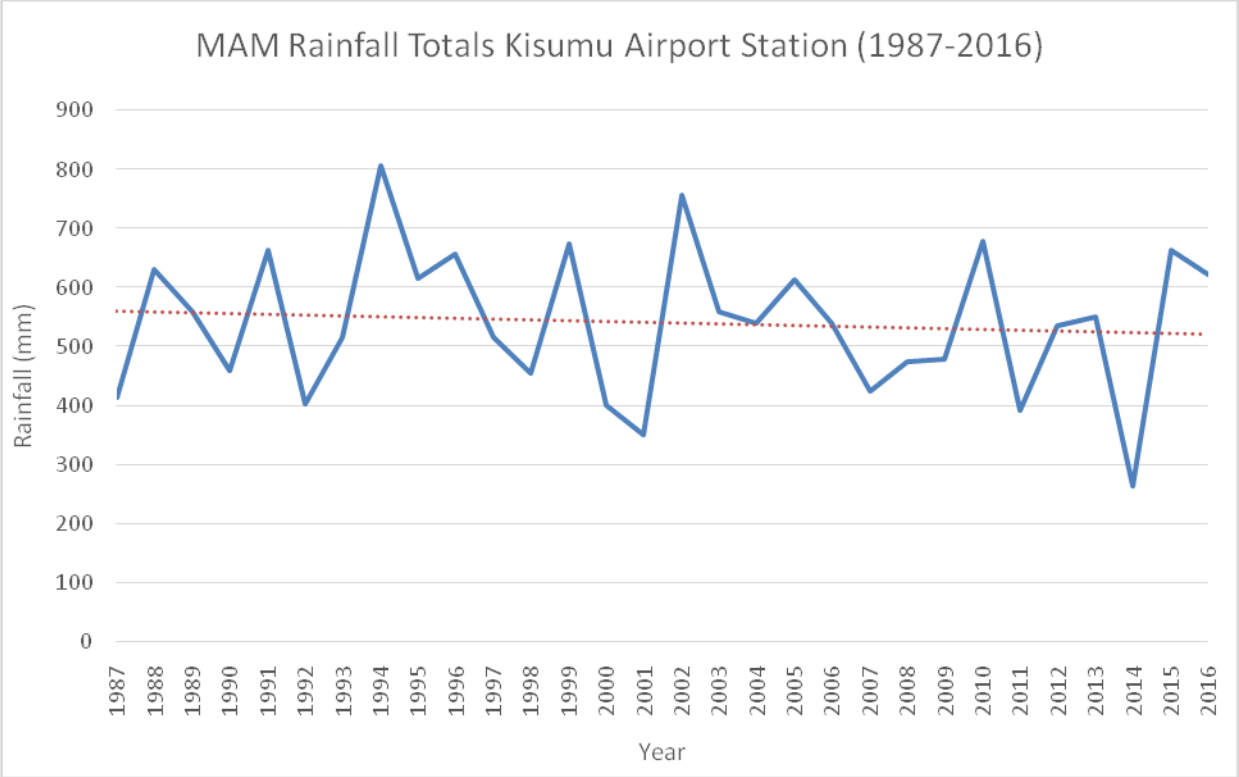

Figure 4.5: MAM rainfall analysis of Kisumu City Airport Station data, 1987-2016.

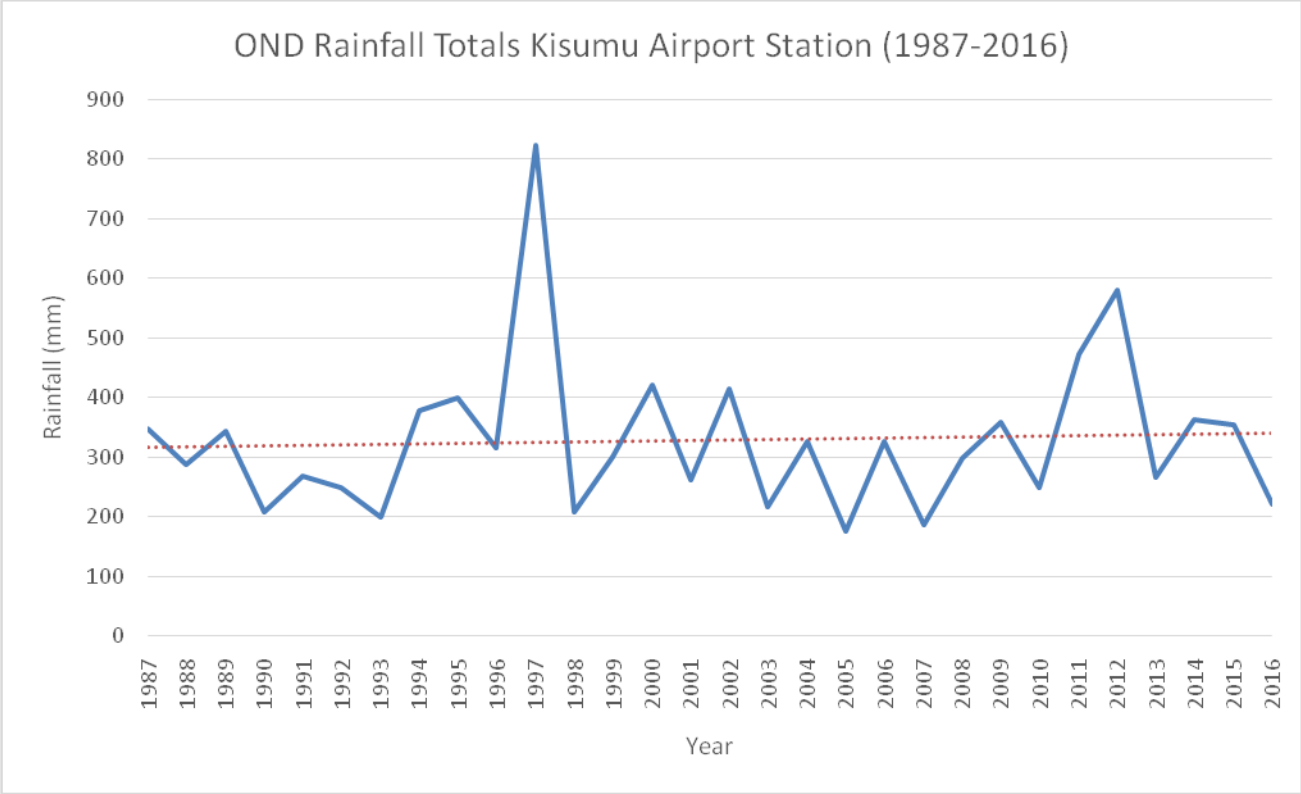

Figure 4.6: OND Rainfall Analysis Kisumu city Airport Station data, 1987-2016

According to OXFAM (2017) the horn of Africa was experiencing a food crisis in the year 2017, and some countries in the horn have experienced rain failure about three times in a row as from 2014. This is in agreement with the observation of the respondents that they no longer see rain in rainy seasons. In Kenya, it is estimated that 3.4 million people in 2018 have been left food insecure with an estimate of half a million of the citizens without access to water (UNICEF, 2018).

Fifty-four percent (54%) of the respondents stated that drought affects the respondent's monthly income and 45% of the respondent's monthly income is affected during flood season because they have to spend more money acquiring medication for climate induced disease. Seventy-five percent (75%) of the residents noted that community water sources are greatly affected by drought which results in severe water shortage, and 79% of the slum dwellers mentioned that the water sources are contaminated during flooding resulting in clean water shortage. The incomes of the respondents are low hence they are not able to

adapt to a changing climate; further, they are made worse off by the impact of climate extremes, which shows the need to build resilience in these communities.

Table 4.2: Frequency of devastating floods in Kisumu City Informal settlements

	Regularity	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	6	1.8	1.8	1.8
	Seasonally	320	96.1	96.7	98.5
	Regularly	3	0.9	0.9	99.4
	Never	2	0.6	0.6	100.0
	Total	331	99.4	100.0	
Missing	System	2	0.6		
Total		333	100.0		

Table 4.3: Frequency of devastating drought in Kisumu City informal settlements

	Regularity	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	19	5.7	5.9	5.9
	Seasonally	231	69.4	72.2	78.1
	Regularly	69	20.7	21.6	99.7
	Never	1	0.3	0.3	100.0
	Total	320	96.1	100.0	
Missing	System	13	3.9		
Total		333	100.0		

4.3 Temperature Trend Analysis

A rise in temperature is one of the indications of global climate change (Asfaw et al., 2017). Annual monthly temperature data was collected for the same period as rainfall data (1987-2016). The mean annual temperature has changed from 23.4ºC to 24ºC the difference is 0.6 ºC (Figure 4.7). The mean annual maximum temperature has changed from 29.9 to 30ºC over the years. The mean annual minimum temperatures have risen significantly from 17 to 18ºC over the same period. The highest temperature was recorded in 2010 (24.4ºC) and the lowest in 1989 (23ºC). The results are consistent with global warming which has increased by an estimated 0.6ºCover the past 100 years (Asfaw et al., 2017). The Paris Agreement aims to keep global average temperature increase to below 2ºCto reduce impacts of climate change.

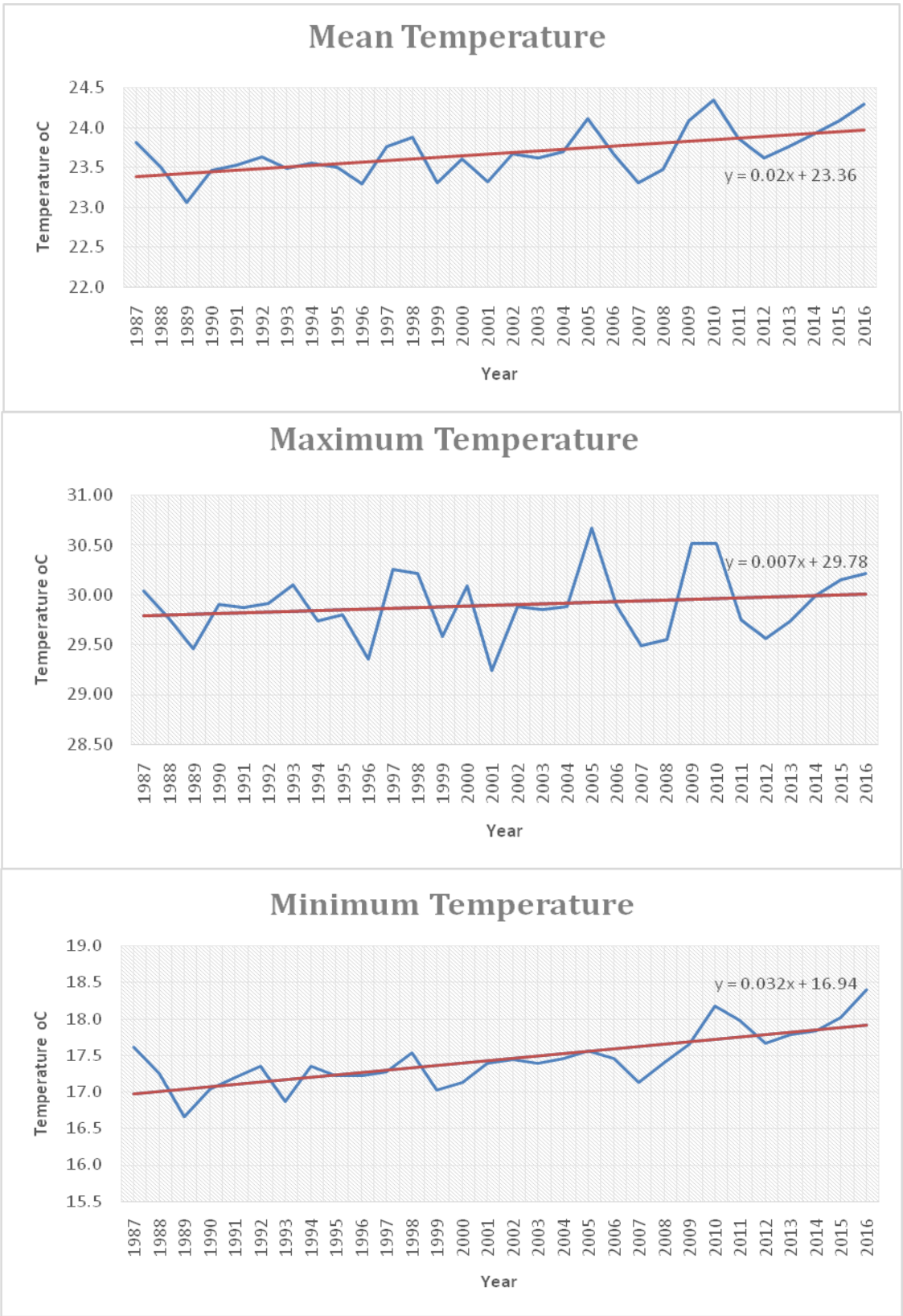

Figure 4.7: Annual mean, maximum and minimum temperature for Kisumu CityAirport Station

Table 4.4: T-test showing significance of (Tmin) trend

t-Test: Two-Sample Assuming Unequal Variances (T min)

	1987-2001	*2001-2016*
Mean	17.20777778	17.69166667
Variance	0.06	0.12
Observations	15	15
Hypothesized Mean Difference	0	
Df	25	
t Stat	-4.44648259	
P(T<=t) one-tail	7.82253E-05	
t Critical one-tail	1.708140761	
P(T<=t) two-tail	0.000156451	
t Critical two-tail	2.059538553	

Table 4.5: T test showing significance of (Tmax) trend

t-Test: Two-Sample Assuming Unequal Variances (T max)

	1987-2001	*2001-2016*
Mean	29.82166667	29.97666667
Variance	0.09	0.13
Observations	15	15
Hypothesized Mean Difference	0	
Df	27	
t Stat	-1.259283421	
P(T<=t) one-tail	0.109353104	
t Critical one-tail	1.703288446	
P(T<=t) two-tail	0.218706208	
t Critical two-tail	2.051830516	

In terms of temperature, the maximum temperature (Tmax) and minimum temperature (Tmin) anomalies reflect climate variability in Kisumu City. The annual rate of minimum temperature change per year was 0.03%and the rate of change for the maximum temperatures was negligible. The highest Tmax anomalies are recorded in 2005 followed by 2009/2010 and the lowest Tmin were recorded in 2001 (Figure 4.8). The highest positive anomaly for Tmin is recorded in 2016 and the lowest in 2002. These anomalies show an indication of

climatic risk because of extreme temperatures. The polynomial regression shows that Tmin has been consistently rising above the mean Tmin for the period 1987to 2016 since the year 2006; both Tmin and Tmax are rising with the latter at a much slower rate than the former (Figure 4.7). To analyse significance of the trend lines, a t-test for the Tmax and T min was done (Table 4.4 & 4.5). The p-value used for the test was 0.05 and both of the t stat calculated values for T max and T min are less than the t criticals meaning that both trends are not statistically significant.

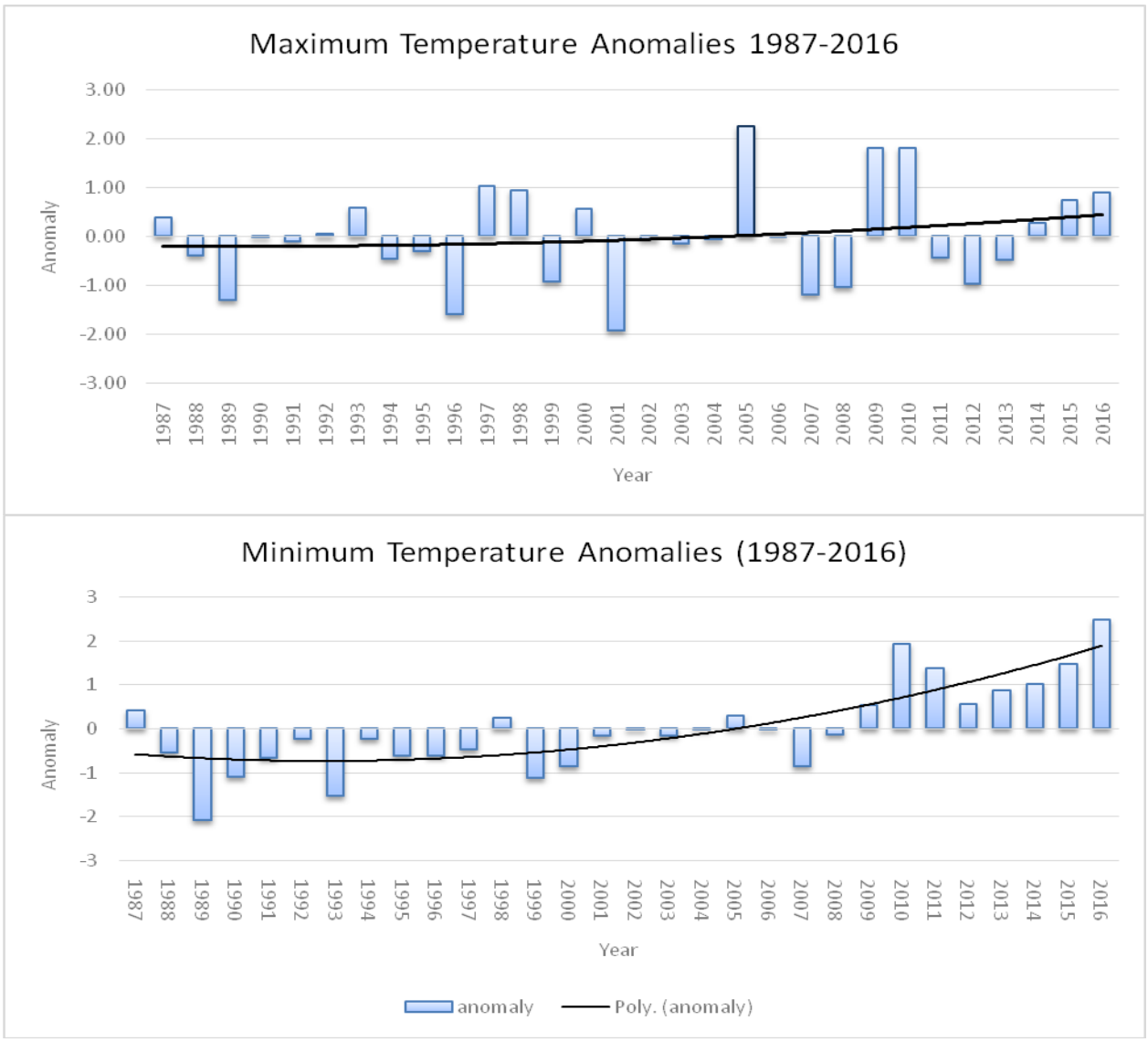

Figure 4.8: Maximum and minimum temperature anomalies for Kisumu Airport Station

4.4 Bio Data of the Respondents

Almost half of the respondents (44%) were aged between 20-29 years of age as shown in figure 4.9 below. This implies a high unemployment rate of youth who were available during the administration of the household questionnaire. The gender composition of the respondents was mostly women with a total of 63% women and 37% male. Most of the women in these villages are housewives and are unemployed and the sole bread winners of their homes are men.

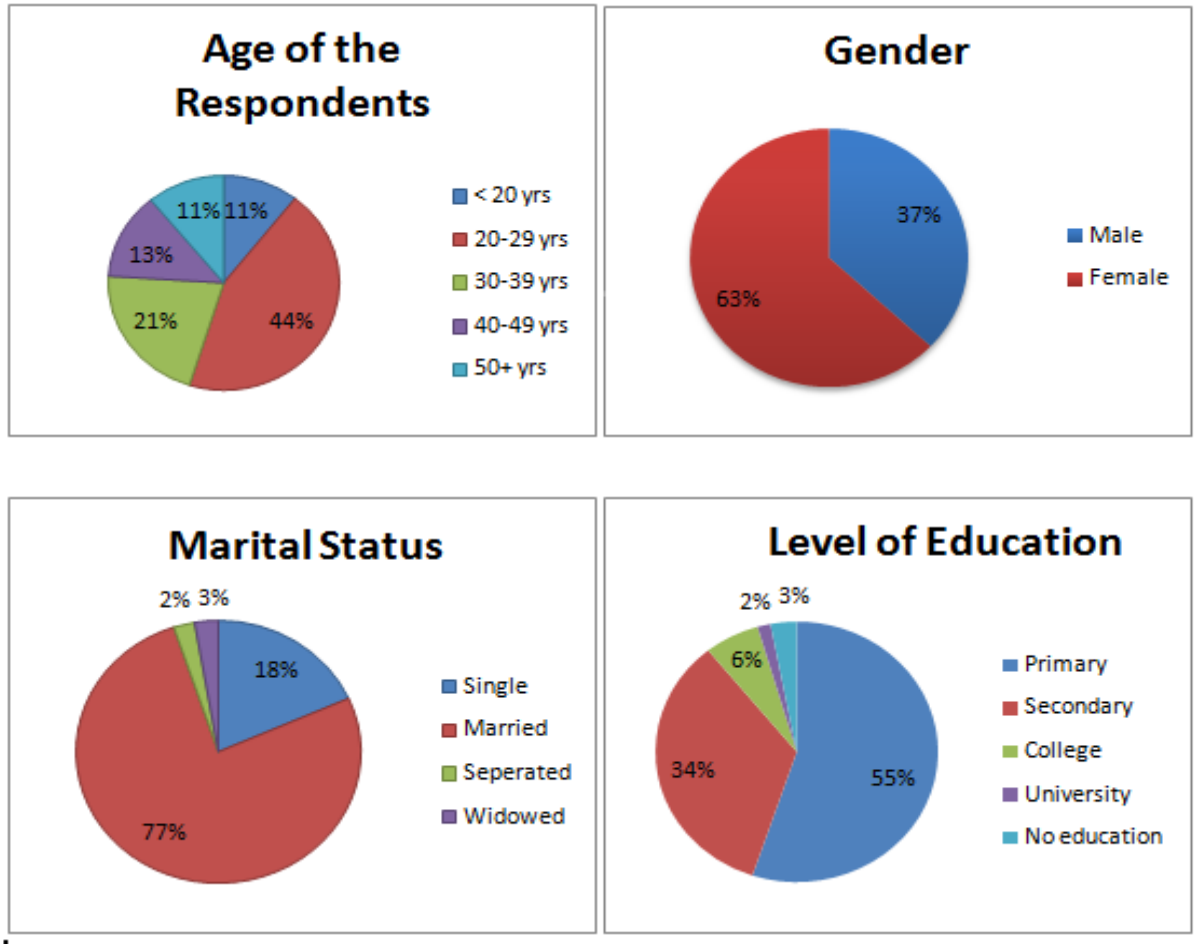

Figure 4.9: Bio data of the respondents in Kisumu city informal settlements showing Age, Gender, Marital Status and Level of Education

Most of the of the respondents interviewed (77%) were married and 18% were single. Almost half of the respondents (55%) have reached primary school level with most women not having the opportunity to proceed to secondary school. Thirty-four percent (34%) of all

the respondents have reached secondary school level. These are mostly men, but many failed to get the opportunity to proceed to university level leaving only 6% having reached university level (see figure 4.9). Three percent (3%) of the population has not received any form of education- this percentage is represented mostly by elderly persons in the villages.

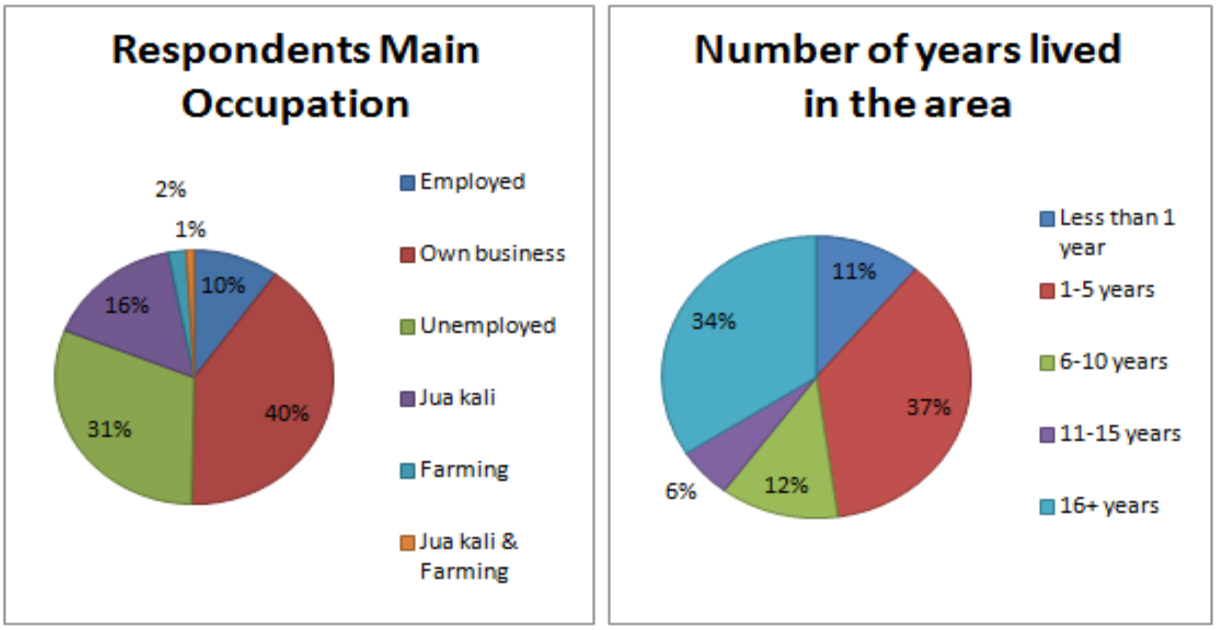

Figure 4.10: Bio data of Kisumu City urban informal settlements respondents' main occupation and number of years lived in the area

The respondents' (40%) main occupation was small businesses which includes water vending, fish mongering, food business, clothes hawking and grain milling. One third of the of the respondents (31%) were unemployed and included school drop-outs and housewives. Sixteen percent of the respondents' (16%) were in *Jua kali* (informal employment); some making a living from masonry -digging mud water from Lake Victoria and making bricks. (Forty-four percent (44%) of the respondents said that they use water for their livelihoods especially in masonry, water vending and food businesses. In the focus group discussions, it was indicated that there is loss of business and no clients during rainy periods and also that general movement is not easy during rainy seasons. During dry season fish business is very low. Most of their income is spent on treatment related to disease outbreaks driven by climate

extremes, and they do not have medical insurance. The greatest problems of the dwellers are low income and job uncertainty.

Thirty seven percent (37%) of the residents have lived in the urban informal settlement for between 1-5 years, and 34% have lived there for more than 16 years (Figure 4.10). The village elders in Manyatta mentioned that they inherited ancestral land from their fore-fathers and that this was the reason why some families cannot evacuate during times of flooding because some of the residents have an attachment to these areas which are prone to flooding.

4.5 Impacts of climate extremes on water supply, quality and use in Kisumu

4.5.1 Water Source

The main source of drinking water in Kisumu City informal settlements is KIWASCO piped water (91 % of the slum residents). The respondents (75%) stated that the KIWASCO water is reliable and 25% of the respondents said the water source was not reliable. This is because when they experience heavy rains the pipes are exposed by flood water, and thereafter there are frequent pipe bursts because of heavy vehicles which damage these pipes. The focus group discussion participants also stated that high temperatures expand and damage the PVC water pipes, resulting in water shortage (see appendix C). KIWASCO Company mentioned that during drought periods they ration water in the area because water levels go down in reservoirs (see appendix B). A representative from the Ministry of Water in charge of urban water services provision stated that the water infrastructure is not resilient to climate extremes because it is old and needs to be replaced. He also mentioned that abstraction of water during dry periods is very difficult because most water reservoirs dry up (appendix B).

Sixty- one percent (61%) of the slum residents use alternative sources of water (figure 4.11). Among these, the users sources as follows, with some using more than one set of sources simultaneously; shallow wells (13%), deep wells (10%), rainwater harvesting (24%), roof catchment (27%), rivers (32%). The rivers constitute a great percentage of the alternative use when the main source is not reliable though during dry spells they dry up. Wandiege Water and Sanitation Company provide borehole water in Manyatta informal settlement. Wamulanda Water Company provides water in Nyalenda. Kudho spring is a water source for

some Obunga informal settlement residents (see appendix C).It has been asserted that KIWASCO water company now has a good coverage in the informal settlements unlike in the past when people used to rely mainly on shallow wells (Okotto, 2015).However, the alternative sources are used because sometimes KIWASCO water might not available and it is expensive for other residents to use KIWASCO water for household activities (washing clothes and bathing); they would only use it for drinking and cooking.

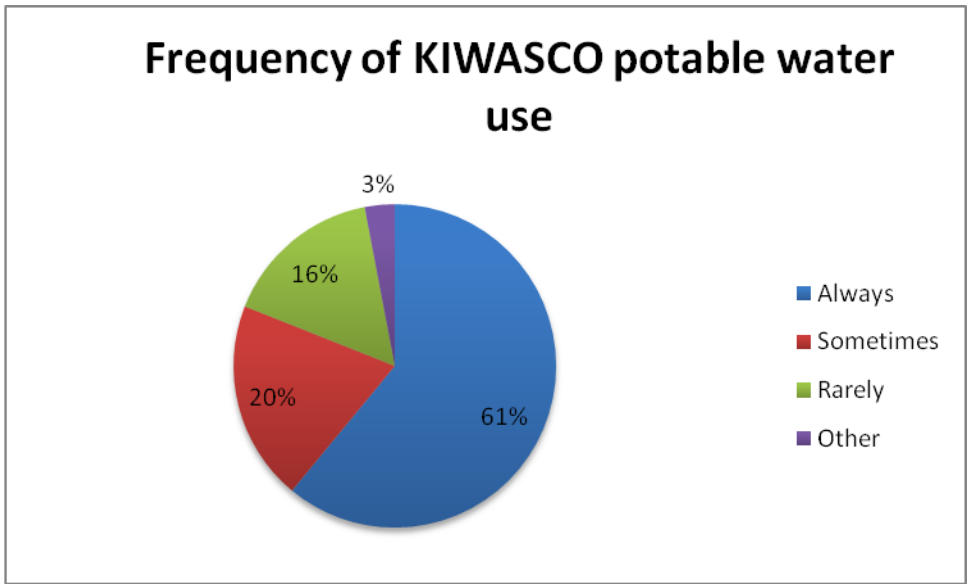

Figure 4.11: Frequency of KIWASCO potable water use fordrinking

4.5.2 Water Supply

Thirty- five percent (35%) of the respondents had clean water less than 10 meters from their houses. About 23% were 10 -50 meters from the nearest water point and 19% were more than 100meters away. A tenth of the respondents walked more than a kilometre in search of water (Figure 9). Some of the participants in the focus group discussions stated that it takes approximately 4hrs during dry periods to get to water points. During the focus group discussions in Nyalenda the participants mentioned that there are normally long queues at water kiosks because of water shortage (see Appendix C), corroborating the UN-HABITAT 2007) observation that the urban poor queue for long hours to collect water from illegal connections and standpipes. However, Foeken (2013) notes that improved access to clean

and affordable water can reduce the time spent in search of water as well as water related conflicts.

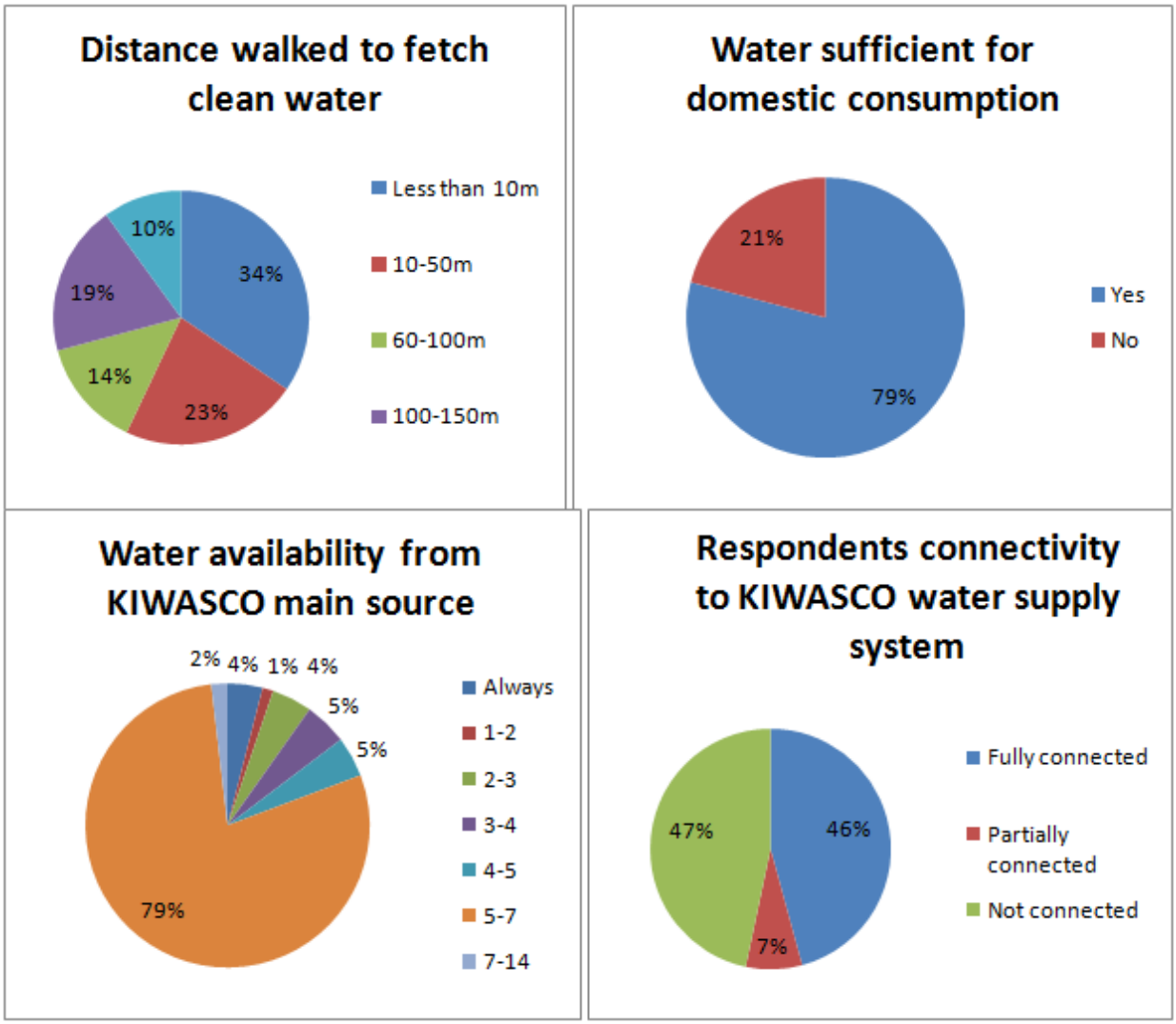

Figure 4.12: Water Supply in Kisumu city urban informal settlements

Most of the respondents (79%) said that water is available five to seven days a week from KIWASCO main source (see figure 4.12). According to Practical Action (2009)62% of the informal settlement dwellers were experiencing shortages weekly, meaning that the availability of water has now improved. However, the urban water provision officer in Kisumu City mentioned that when a pipe bursts because of extreme heat or flooding it can

take up to a month before repairs are undertaken (see Appendix B). Almost half of the respondents (46%) are connected to KIWASCO water supply system (Figure 4.12) today as compared to 40% in 2005(Practical Action, 2008).

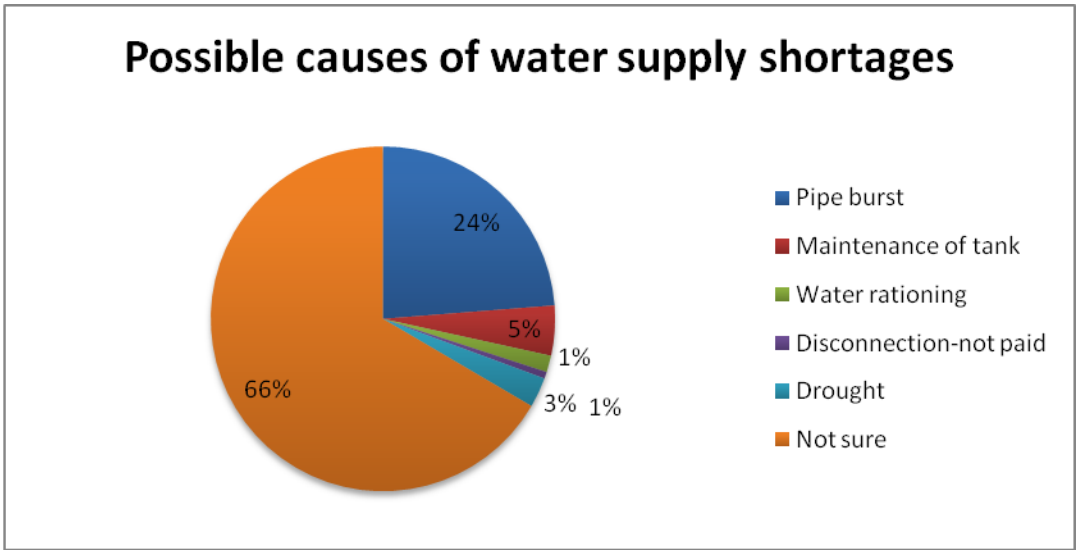

Figure 4.13: Possible Cause of Reduced water supply

About 34% of the water supply shortages in the urban informal settlements are due to pipe bursts especially on major roads. During the focus group discussion in Nyalenda the residents also revealed that pipes are cut by the slum dwellers who are not connected to KIWASCO water in order to access that water (see Appendix B). This was confirmed by Mr Fred Nyongesa of WRA during key informant interviews (see Appendix B). It was also reported that, in 2007, KIWASCO had water revenue losses of 66% due to leakage of pipes, vandalism and late payment of water bills by clients (Practical Action, 2008). However,66% of the respondents were not sure what causes water supply shortage. A small percentage of the respondents (5%) said that it might be a related to tank maintenance. Only 1% of the respondents were aware that sometimes KIWASCO rations the water (see figure 4.13). However, a representative from Ministry of Environment in Kisumu mentioned during an interview stated that KIWASCO has too much expectations on the slum dwellers in terms of

payment for water use. They cannot afford and KIWASCO will not want to supply water for free because it is a profit-making company.

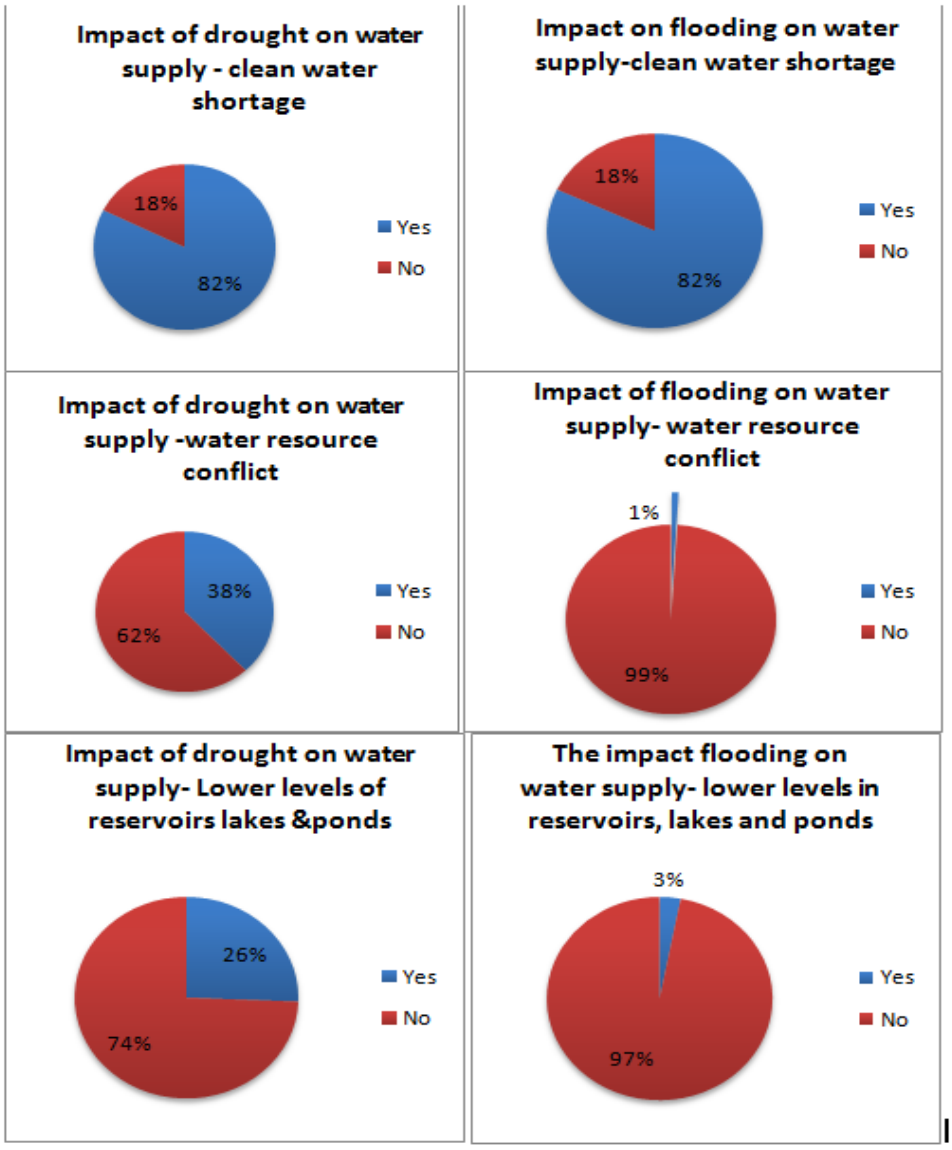

Figure 4.14: Impacts of drought and flooding (water shortage, water resource conflict and lower levels, lakes and ponds)

Eighty two percent of the respondents said that flooding and drought periods greatly impact on availability of clean water and contribute to water shortages in the area (Figure 4.14). The respondents also stated that drought causes water resource conflict at water points or at water vendor kiosks especially amongst women who use the water more frequently; normally some

residents might want to skip the queue of water or carry water in bulk. The residents (99%) also mentioned that during flooding water is in abundance therefore there are not much water related conflicts because people harvest water. Twenty six percent of the respondents said that drought decreases the water levels of reservoirs, lakes and ponds, while 97% said that this not the case during flooding (see figure 4.14).

KIWASCO and Wandiege Water and Sanitation Company indicated, during key informant interviews, that they have peak sales and they make huge profits during drought periods. In the discussion groups, the informal settlement dwellers also acknowledged drying up of streams and natural springs. They also stated that the water becomes more expensive, rising from 20 shillings to 30 shillings per jerry can during droughts. The drought impacts also include: shallow well water becoming saline; theft of water meters; reduction of water levels in wells; death of domestic animals; dust storms and reduced water accessibility (see appendix C).

During rainy season the communities mentioned frequent pipe bursts which contaminate the water, and due to this contamination tape worms are found in the water. Typhoid was mentioned to be prominent during this period. Water vendors have no access to the roads to sell water during flooding. Transport during heavy rains is expensive and it costs 100 shillings for the residents to send their children to school with *bodaboda.* There are a lot of deaths at this time, including drowning of children in flood water as they go to and from school; this has led to adults taking extra time to accompany and monitor their children as they go to and from school and requires a lot of monitoring for school children to go to school.

The impact of climate change on water supply is more pronounced by heavy flooding and severe drought that are accompanied by disease epidemics. Changes in rainfall and warming of temperatures will likely continue to impact water supply and quality (EPA, 2002). The interviews made in the communities revealed that the climatic changes are unpredictable and drought periods have become prolonged, showing the urgency to building the community's resilience.

4.5.3 Water Quality

In terms of water quality,76% of the respondents noted that the water is clear in colour, while 17% said the water is turbid at times especially during dry periods. Seven percent of the respondents noted that the water comes with suspended matter especially during flooding (see figure 4.15). The respondents were also asked about the taste of the water: 62% reported that the water has a good soft taste while 24% reported it to have a bitter and chlorine taste. Seven percent (7%) of the respondents said it was salty and another 7% reported the water to have a bad and muddy taste (Figure4.16). Twenty six percent of the respondents stated that the water comes with a very bad smell. The EPA 2002 states that; "*Water quality suffers when there is increased rainfall, this is because the heavy rainfall can cause difficulties with water infrastructure and sewer systems which are overwhelmed by large amounts of water.* "This has been established in the informal settlements.

Figure 4.15: Water from the main source with suspended matter in Obunga

Half of the respondents (50%) stated that they boil or add bleach/chlorine to the water, 23% boil, 17% add water guard and the other 10% of the respondents do not treat the water because some feel that the water has too much chlorine already and some just drink it without treatment. Twenty-eight percent of the respondents have suffered from diarrhoea because of

the water, 42% say that they have suffered from typhoid, and 5% have noted that they have had worms. Sixteen percent have reported cholera cases especially during dry periods.

These results show that some of the communities have minimal knowledge on treating water. The representative from WRA during the key informant interview urged that the communities should be sensitized in this regard and should also be involved in activities carrying messages of climate change impacts. Environmental contamination is associated with poor waste management in the urban informal settlements which is exacerbated by climate extremes. This contamination affects water quality resulting in water borne disease (Opisa et al., nd), which is the reason why the residents are affected by typhoid and cholera as shown by the results presented.

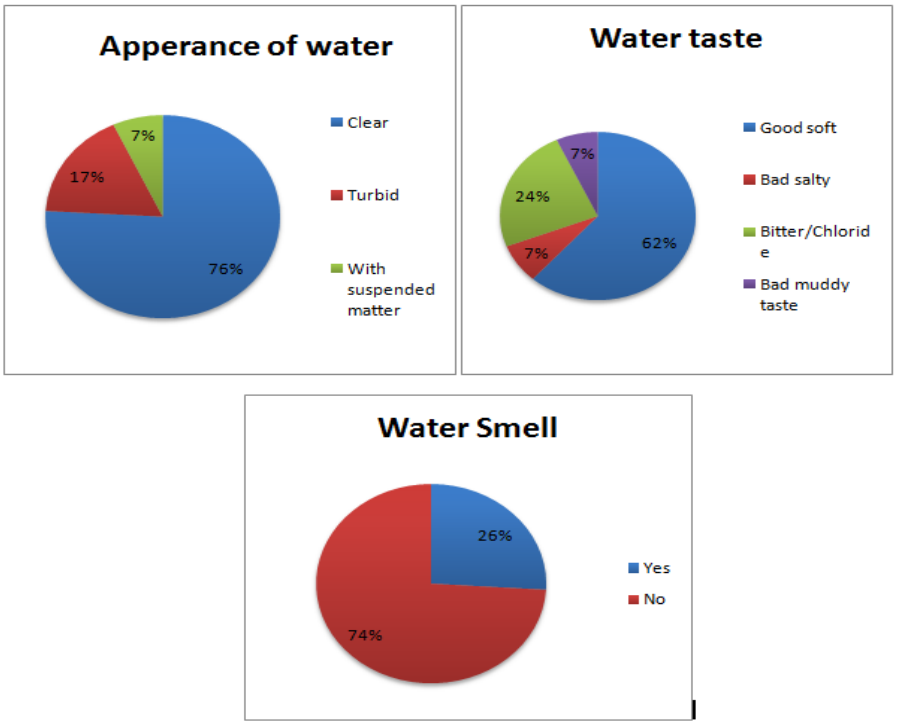

Figure 4.16: Water quality in Kisumu City informal settlements

4.5.4 Water Use

The main use of KIWASCO water in settlements is drinking for majority of residents (99%).The other main uses of water apart from KIWASCO water include; urban agriculture (12%), construction (23%), and livelihoods (44%). Other minor uses which were revealed

during the focus group discussions include: brewing of illicit liquor, raring of domestic animals, cattle dipping and car washing. The KIWASCO representative interviewed confirmed that a greater percentage of the slum dwellers use KIWASCO water for drinking and cooking only, and a small percentage uses KIWASCO water for personal hygiene and other uses (see appendix B). These results show that the residents might not afford KIWASCO water to use it for personal hygiene or it could indicate a serious shortage of water in urban informal settlements.

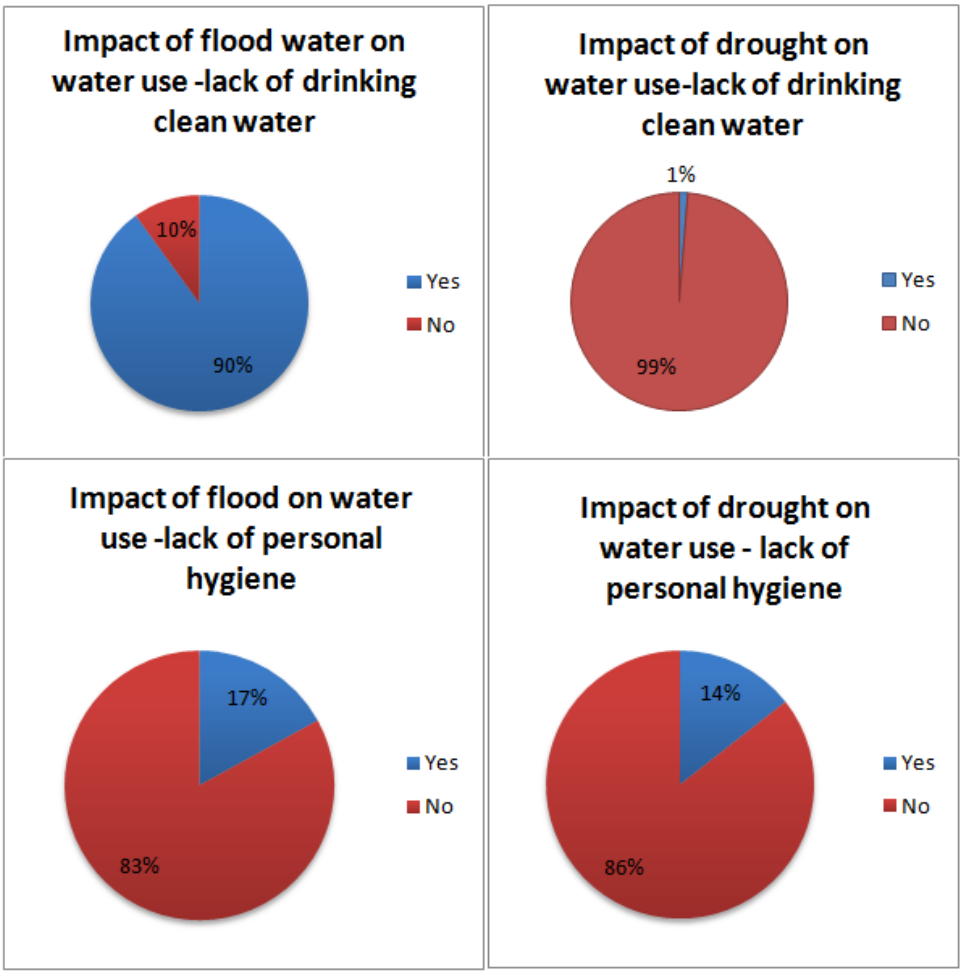

Figure 4.17: The Comparison of the impact of flooding and drought on water use (Lack of drinking water and personal hygiene

The impact of flood water affects the water use. Flooding causes lack of clean drinking water. Almost all of the respondents (99%) were in agreement that clean water for drinking is

scarce during flooding because the flood water inundates the area and contaminates open fresh water sources like rivers and shallow wells. Kisumu City water table is very high, and the infiltration capacity is low. Flooding contaminates the water sources making clean water a big challenge during this time (Figure 4.17). Flooding also impacts on the respondents' personal hygiene (17%) and drought has roughly the same impact (14%) on the respondent's personal hygiene (Figure 4.17) as they might have to reduce the number of times they bath in a week. The residents mentioned that sometimes the alternative water sources like the rivers or streams are so contaminated that they are not able to use this water for domestic use. However, according to Foeken (2013), 65% of the urban informal settlements dwellers in Kisumu reduced water use in 2009 because of severe drought. A strong relationship between household daily income and per capita water use in Kisumu was found by Wagah et al. (2010), that the higher the income the more the use and the lower the income the lower the use. This clearly indicates that the water provided by KIWASCO is too highly priced for the slum dwellers to afford.

4.5.5 Social impact

Sixty seven percent of the respondents noted that climate extremes affect their health status. During drought periods, 29% were not so much affected and 4% were not affected. During flooding, 72% of the respondents face a lot of health challenges while 25% stated they were not affected that much and only 2% of the respondents were not affected. Forty percent of the respondents also stated that during flooding periods a lot of people lose their lives as compared to the drought period. This is because a lot of people drown trying to cross River Nyamasaria and the infant mortality rate is very high at this time due to higher exposure risk to climate related diseases.

Extreme (high) temperatures have been reported to cause water pollution problems in the natural sources of water like rivers. Eighty three percent (83%) of the respondents highlighted that higher temperatures are associated with algae in natural water sources like rivers (see table 4.6). The annual mean temperature of Kisumu City shows an increasing trend (see figure 4.7) that suggests that such experiences may increase in the future. Climate extremes affect the livelihoods of the residents and their day to day work in informal settlements, for example, food business vendors and construction workers would have to

walk long distances to look for water in dry periods. Fifty eight percent (58%) of the respondent's livelihoods are affected. Fifteen percent are not so much affected and 6% are not affected.

Table 4.6: The impact of an increase in temperature and water pollution problem in natural sources

	The extent to which Residents are affected	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not so much	40	12.0	12.8	12.8
	Very much	258	77.5	82.7	95.5
	Not affect	13	3.9	4.2	99.7
	4	1	0.3	0.3	100.0
	Total	312	93.7	100.0	
Missing	System	21	6.3		
Total		333	100.0		

Sixty nine percent of households highlighted that flooding damages critical infrastructure for water supply because flood water exposes the water pipes which are damaged by heavy vehicles. During drought periods, 55% of the respondents said critical infrastructure for water supply is damaged by the residents themselves because a greater number of them are not connected to KIWASCO piped water so in times of dry spells they cut pipes to access the water because water is very scare at this time.

As seen in the results, the social impact of climate extremes is quite high as it affects the day-to-day activities of the slum dwellers and the communities' well-being. The results show that the communities are unable to adapt because of limited resources.

4.6 Discussion

The UK Met Office (2011) stated that Kenya has a high-water security threat, but goes on to say that climate change will have a minor impact on water supply in Kenya beyond 2030 and probably some parts of the country will experience a decline after 2050; this is based on research findings of GCM (Global Climate Model) simulations by the Avoiding Dangerous Climate Change programme (AVOID) programme for Kenya sponsored by UK. The IPCC AR4 in 2007, however, noted the potential of increased rainfall and flooding over East Africa in the future. According to the rainfall analysed in this chapter, the results show that the

rainfall is increasing though the trend is not statistically significant over Kisumu City. Based on limited observational evidence research done by Song et al. (2004), the simulated diurnal cycle for precipitation over the Lake Victoria Basin has been consistent in terms of frequency and amount. The rainfall trend is also characterised by precipitation extremes which have led to deficit and surplus of water supply as the city has experienced severe drought and flooding. The availability of clean water supply still remains uncertain in Kisumu City as the water infrastructure is not rehabilitated and is not in a state to cope with a changing climate.

The results also show that the temperatures are warming as the minimum temperatures are increasing faster than the maximum temperatures. Warming has been noted in Kenya dating back to 1960 and most observed extreme temperatures are linked to rainfall cycles (UK Met Office, 2011). High temperatures have damaged water pipes which supply the residence with water. High extreme temperatures have also contributed to climate induced disease such as malaria. Extreme heat conditions have serious negative impacts which have been experienced in recent years which have been recorded since 2015 in Kisumu City. If the Paris Agreement which aims to keep global average temperature increase to below 2ºCto reduce impacts of climate change is not adopted, then temperature effects on urban water infrastructure in cities like Kisumu may become increasingly more severe.

The results show that the main water sources in Kisumu City have changed. Kisumu Water and Sewerage Company (KIWASCO) now have a good coverage in the informal settlements which could indicate development efforts in the area by the county government to achieve sustainable development goal 6. Kisumu City informal settlements used to rely on water from shallow wells because of limited access to KIWASCO water (Okotto, 2015). The(KIWASCO) water is mainly used for drinking and cooking purposes which and is available at least 5- 7 days a week as most the respondents mentioned, meaning that alternative sources are accessed for two or less days in a week. In 2010 UNICEF/ WHO published a report stating that Africa accounts for 37% of people who access water from unsafe sources. It was estimated that more than ten countries in the world have 50% of people who do not have access to safe water supply (World water, 2010). In Kisumu City 45% of the residents still access water from unsafe sources as seen in section 4.5.1. This percentage exceeds the Africa average percentage which accesses unsafe water sources.

High incidence of flooding and drought affects water quality and supply of clean water in the Kisumu City urban informal settlements. The water contamination is high especially during flooding because of adjacent pit latrines. Heavy precipitation is associated with water quality challenges and drought also deteriorates water quality in urban areas (NOAA, 2018). Globally, impaired water quality is an issue of growing concern it limits water resources for drinking, domestic use and other uses (Michalak, 2016). Most water quality issues are exacerbated by climate extremes. The urban informal settlement dwellers have faced severe health challenges particularly water-borne diseases which were found to be dominant and associated with climate extremes.

The impairment of water quality due to severe drought and flooding has made the urban informal settlement dwellers stop using some open sources of water like rivers which are highly contaminated to the extent where the colour of the river water changes. The residents normally use river water for bathing, agriculture and other domestic use. The residents have to reduce the number of times they shower when the water is contaminated, or they have to discontinue use of that water. However, this might not be the only factor; an increase in global population will lead to greater water use and demand of water and it also means more water pollution/ contamination.

4.7 Conclusion

The study shows that the urban informal settlement dwellers suffer severe impacts of climate change on water supply. The rainfall and temperature projections still remain uncertain, while climate change continues to pose severe impacts on water supply. Kisumu City urban informal settlements dwellers are highly affected by climate flooding and drought and failure to adapt to a changing climate will leave an enormous number of urban informal settlement residents in extreme poverty.

Climate change needs to be taken seriously by the county government and not overlooked. There is need for sound adaptation strategies to sustain water supply as some parts of the continent in South Africa have started to experience serious water shortage where they are anticipating a situation where taps have no running water. The county budget needs to

include contingency planning for climate extreme events and be incorporated in the county's development planning process with a specific focus of the urban poor.

To allow sustainability of water supply, there is need for investments in climate resilient infrastructure, rehabilitation of existing water infrastructure and the county government to support the vulnerable populations. The Kisumu County needs to pay particular attention to the informal settlement dwellers as they are the most vulnerable and they have the least resources to cope with a changing climate.

CHAPTER 5: VULNERABILITY OF KISUMU SLUM DWELLERS TO IMPACT OF CLIMATE CHANGE RELATED EXTREME EVENTS

5.1 Introduction

This chapter presents results from objective two. Vulnerability indicators were identified and classified in two groups at community level (environmental) and individual level/household level. The vulnerability indicators were identified in section 3.5 and assessed and quantified in this chapter. This chapter assesses and quantifies the level of vulnerability of the slum residents to the impact of climate extremes in order to find entry points for disaster risk reduction and adaptation measures for climate change impacts. The vulnerability indicators include income, educational levels, sanitation systems, water supply systems and community health.

5.2 Environmental Vulnerability

5.2.1 Sanitation and drainage

The main source of human waste disposal in the informal settlement is pit latrine as shown in the (table 5.1). Nyalenda has the highest percentage (9%) of the respondents who use flying *toilets* meaning they have no facilities. The respondents use pit latrines because they are not costly to construct unlike flush toilets (table 5.1). During flooding the residents mentioned that these pit latrines overflow because the pit latrines are full, and the slum residents do not have money to empty the pits (see figure 5.1). The human waste is carried by the flood water into the resident's houses exposing them to disease risk. Kisumu City has 10% sewerage coverage this is the reason why the urban informal settlements rely on pit latrines which are not adequately maintained (UN-HABITAT, 2006).

The distance between the water source and toilet facility determines the level of risk of to the informal settlement dwellers. The residents are at risk during flooding, because flood water contaminates water sources. The distance between the water source and toilet facility for more than half of the residents (60%) ranged from 10 to 70 meters, but for 33% of them it was more than 100m (table 5.2).

Table 5.1: Main repository for human waste disposal (%). VI – Vulnerability Index

Name of Informal Settlement	Pit latrine	Flush Toilet	No facility	Total	VI	Criteria for determination of VI
Nyalenda A	89	2	9	100	3	1) 0-30% of the population have access to flush toilet facility (low vulnerability - 1) 2) 30-70% has moderate vulnerability (Medium vulnerability - 2) 3) 70-100% of the population Most (79%) of the respondents stated that they access to pit latrines (High vulnerability -3)
Nyalenda B	88	8	4	100	3	
Manyatta A	100	0	0	100	3	
Manyatta B	92	4	4	100	3	
Otonglo	96	0	4	100	3	
Obunga	92	2	6	100	3	
Cumulative Total	93	2	5	100	3	Kenya Vision 2030 aims to have improved water and sanitation available and accessible for all its citizens

Figure 5.1: Pit latrine in the urban informal settlements of Kisumu City- Main source of waste disposal

Table 5.2: Distance between toilet and water source facility in all the settlements

Distance between water source and facility	Number of residence Percentage
Less than 5m	7%
10-20m	14%
30-50m	28%
60-70m	19%
More than 100m	33%

In terms of garbage collection 45% of the respondents acknowledged that garbage was not collected by the county government. About a quarter of the residents (25%) stated that the major problem with solid waste management in the area is lack of waste containers. garbage is collected sometimes by the National Youth Service (NYS) and 28% of the respondents pay people to collect their garbage (table 5.3).The other 21% of the respondents blamed it on lack of regular collection. Twenty two percent (22%) of the respondents also thought the problem emanated from an increasing population. Kisumu City solid waste management is inadequate with most of the residents having waste which remains uncollected (Gutberletet al., 2016). This uncollected waste is left on the road sides and in open spaces sometimes, blocking drainage in the area which mixes with waste from floods, leading to hazardous conditions in the informal settlements (Oloko et al., 2016). The respondents were also asked how they dispose their refuse. Most of the respondents (33%) said they burn the refuse, 11% dump in nearby bushes and 5% of the respondents dump in Lake Victoria.

Table 5.3: Frequency of garbage collection

	Garbage collection	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Daily	90	27.0	28.3	28.3
	Weekly	78	23.4	24.5	52.8
	Monthly	8	2.4	2.5	55.3
	Not collected	142	42.6	44.7	100.0
	Total	318	95.5	100.0	
Missing	System	15	4.5		
Total		333	100.0		

The majority of the respondents in the settlements noted that they have limited drainage systems. Sixty-nine percent of the respondents highlighted this as a major challenge in the settlements (see figure 5.2). Eighty-six percent (86%) also stated that there are no flood outlets which make them vulnerable to flooding in their homes. According to the Star Newspaper in November 2015, the county government and the Kisumu City management partnered to set aside a budget of 1.4 million to rehabilitate drainage systems in Kisumu City. This is because the systems were prone to blockage during the rainy season which caused extreme flooding in the city. However, some of the communities dug trenches to create flood water outlets during rainy season though they need the local government support.

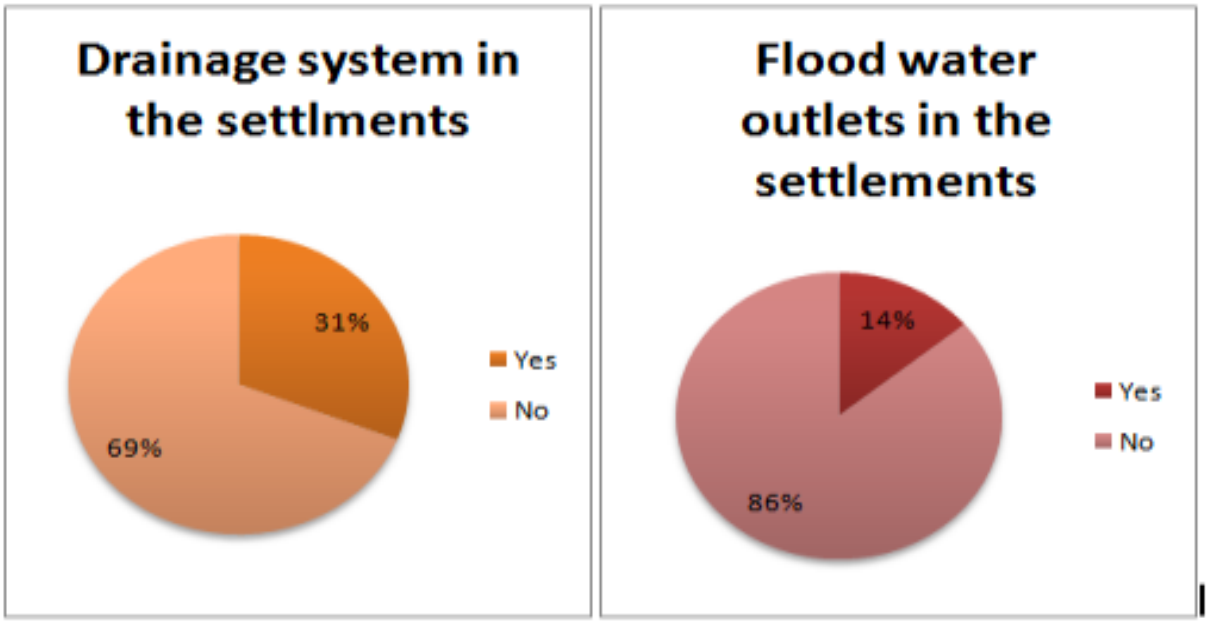

Figure 5.2: Drainage and flood water outlets

5.2.2 Water Supply

The Standard newspaper on December 1st 2017reported that Kisumu could face serious water shortage by 2030 because of lack of adequate water supply infrastructure. This statement was confirmed by Mr Charles Okaka, the urban water services provision officer of Kisumu County, highlighting the need to rehabilitate old and worn out infrastructure and investing in new water supply systems (Appendix B). The growing population in Kisumu has placed

pressure on available water resources and Table 5.4 shows the current status of access to water supply in Manyatta, Nyalenda, Obunga and Otonglo.

Table 5.4: Access to main sources of water supply (%) VI- Vulnerability index

Area	Fully connected	Partially Connected	Not connected	VI	Criteria of determination of VI
Kisumu informal settlements (Nyalenda, Manyatta, Otonglo & Obunga)	47%	47%	7%	2	1) People with 0-30% access to the main water source (High vulnerability-3) 2) People with 30-70% access to the main source (Medium vunerability-2) 3) People with 70-100% access to main water source have (Low vulnerability-1) SDG goal 7 aims at ensuring access to water and sanitation for all by 2050

As discussed in section 4.2.2, almost 80% of the residents mentioned that water from KIWASCO (the main source) was available 5-7days a week. The possible reason for the unavailability of water /water scarcity from the main source was due to damaged water infrastructure or old and worn out water supply systems. The alternative sources of water apart from the main source include: boreholes, shallow wells and rivers as seen in section 4.2.3.

5.2.3 Biophysical environment vulnerabilities

The (IPCC, 2007) states; "*The most vulnerable settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanization is occurring*. "The urban informal settlement dwellers in Kisumu City live in such conditions. SDG 11 advocates for sustainable cities and communities and it aim by 2030 ensure access to adequate and safe affordable housing and basic services and upgrade slums. Their livelihoods are also dependant on natural resources like water. This

indicates high vulnerability of the slum residents to flooding and drought. This vulnerability indicator index is 3 because most of the communities have unsafe living conditions.

The respondents were asked during which months they observed the highest water levels in the river. Eighty-one (81%) of the respondents mentioned April, May, and June and 13% of the respondents mentioned in October, November, and December i.e. the long and short rain seasons, respectively. Sixty-three percent (63%) of the respondents noted less than half a meter as the highest level of water seen in their houses during periods of heavy rains, while 13% who live near the river mentioned that the level of water can reach between half a meter to a meter in depth. Seventy-one percent (71%) indicated that high floods are experienced at the beginning of the rainy season and 21% mentioned during the middle of the rainy season. Forty-nine (49%) of the respondents also mentioned that the rate at which soil drains takes a little longer than before, which means the rainfall would have exceeded infiltration capacity considering Kisumu water table being very high.

The respondents were also asked if they still experience rainy seasons in October, November and December. Seventy one percent (71%) mentioned that rainfall in the October November and December wet season is failing and sometimes it is dry and they do not receive rains. Fifteen percent (15%) mentioned January, February and March as being a dry period. Ten percent (10%) mentioned July August and September as dry periods. Sixty-one percent (61%) indicated that the lowest levels of the rivers Nyamasaria/Kibos are seen in the dry periods and are less than 1metre depth. Thirty two percent (32%) say that sometime the river dries up. Kisumu City is known to be an area with abundant rain hence the rivers drying up indicate prolonged drought. The WRA representative was in agreement that the seasons have changed and are now unpredictable (see appendix B).

Table 5.5: Respondents perception of climate change

	Hazard	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Floods	25	7.5	7.8	7.8
	Drought	50	15.0	15.6	23.4
	Both drought & floods at different times	245	73.6	76.6	100.0
	Total	320	96.1	100.0	
Missing	System	13	3.9		
Total		333	100.0		

Seventy-seven percent (77%) of the respondents perceive climate change in their area as both flooding and drought at different times. Sixteen percent (16%) thought that climate change is drought and 8% thought climate change was flooding in their area. Most of the respondents (83%) receive climate information through the radio and television, some through *barazas* and 4% through religious gatherings. However, the communities do not trust climate information issued by the Kenya Meteorological Department (KMD), because they say that their predictions are not accurate. For example, sometimes they are evacuated when they expect heavy downpour, but it does not happen. The communities prefer to use their own indigenous knowledge systems to predict climate. Although some of the key informants (Appendix B) thought that the slum dwellers are unaware what climate change is, climate information has been seen as increasingly important as rapid urbanization is taking place coupled with an increase in population growth and environmental and natural resource degradation (CCAFS,2015).

5.2.4 Roads and pathways

Many of the urban informal settlements in Kisumu City have not constructed roads and have poor infrastructure (Maji Data, 2008). The urban services are very minimal. The roads and pathways are mostly made of earth and vehicles cannot access these settlements. Eighty six percent (86%) of the households have no access to tarmac roads (Table 5.4). This makes the residents general movement very difficult. Eighty two percent (82%) of the existing infrastructure (roads and small pathways) within the area destroyed during flooding. Eighty three percent (83%) of the households have no access to the important facilities in the area which include clinics, dispensaries and churches.

Table 5.4: Accessibility to major roads (%) VI- Vulnerability index

Accessibility to tarmac roads during flooding	Yes	No	VI	Criteria of determination of VI
Manyatta, Obunga, Otonglo & Nyalenda	14	86	3	1. 70-100% of the population have no access to roads (High vunerability-3) 2. 30-70% has moderate access to roads (medium vulnerability -2) 3. 0-30% have access to major roads (low vulnerability-1) 4. Kenya Vision 2030 aspires for a country firmly interconnected through a network of roads, railway, ports, waterways and telecommunications as well as adequately provided energy. SDG 9 aims to facilitate sustainable and resilient infrastructure development

5.3 Individual /Household vulnerability

5.3.1 Income

Thirty –one percent (31%) of the respondents have no source of income (table 5.5) which shows this community has low adaptive capacity to climate extremes. Only 19% earn money above Kshs. 5000 monthly. According to the Government of Kenya the minimum wage for Kisumu City per month is Kshs.12 926. Most of the respondents live below the poverty line which show high vulnerability of the residents as poverty exacerbates the level of suffering when disaster strikes. The poverty line headcount ratio is $1.90 per day according to the World Bank in 2011. Most of the work locations for the urban poor include industrial areas and downtown which include the CBD industrial area, Kibos and Otonglo which provide only 30% of employment (UN-HABITAT, 2005). The *bodaboda* has created income for the young people in the area. However, job insecurity and low income still remain a major challenge in the informal settlements (UN-HABITAT, 2005). The percentage of the unemployed is very significant which shows low adaptive capacity.

Table 5.5: Respondents household income (%) VI- Vulnerability index

Monthly income brackets (in Kenya Shillings)	Number of households in each bracket (%)	VI	Criteria of determination of VI
1000 and below	12	3	1. People with income 10000 and above have (low vulnerability-1) based on the average least expected income which one is supposed to earn this is considered the least vulnerable group in Kisumu informal settlements constitutes business people 2. People with income between 5000-10000 have (medium vulnerability-2), based on those who depend on wages of employment 3. People with income 5000 and below (High vulnerability-3) lowest income group in Kisumu informal settlements Minimum wage in Kisumu city is Kshs 12926 for the lowest carriers' home
1000-5000	28	3	
5000-10000	19	2	
10000 and above	10	1	
No source of income	31	3	
Cumulative Total	100	3	

5.3.2 Energy

Nyalenda A and B have the highest percentage of residents who are connected to electricity (79 and 90%, respectively) and the lowest is Otonglo with 50% (Table 5.6). The average percentage of respondents with access to lighting from the main source which is Kenya Power and Lighting Company is 63% (Table 5.6). The main use of electricity in the informal settlements is for lighting only. The electricity is illegally connected in some of the settlements from Kenya Power Lighting Company (KPLC) grid. Forty-three percent (43%) of the respondents use Kerosene lamp which is less expensive than electricity, but this type of fuel negatively affects human health. Fourteen percent (14%) of the respondents also mentioned that they use solar lamps as an alternative for lighting. Solar lamps are sometimes distributed by the Government of Kenya especially for flood victims during rainy season. The urban informal settlement dwellers need eco-friendly energy sources which are not hazardous to their health.

Table 5.6: Households with access to main lighting Electricity fuel (%) VI- Vulnerability index

Name of Informal Settlement	Yes	No	VI	Criteria of determination of VI
Nyalenda A	79	29	2	1. Households with access to electricity from 70-100% have (Low Vulnerability - 1), based accessibility of electricity in Nyalenda and Obunga is considered least vulnerable; 2. Households with access to electricity between 30-70% have (Medium Vulnerability - 3. Households with access to electricity from 0-30% have (High Vulnerability - 3). Kenya Vision 2030 aims to enhance power generation capacity, increase access to electricity, development of new and renewable sources of energy and capacity building of the energy sector.
Nyalenda B	90	10	1	
Manyatta A	53	47	2	
Manyatta B	69	31	2	
Otonglo	50	50	2	
Obunga	77	23	1	
Cumulative Total	67	33	2	

Table 5.7: Types of fuels used for cooking

Firewood	-	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	155	46.5	51.5	51.5
	No	146	43.8	48.5	100.0
	Total	301	90.4	100.0	
Missing	System	32	9.6		
Total		333	100.0		
Charcoal	**-**	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Yes	211	63.4	70.1	70.1
	No	90	27.0	29.9	100.0
	Total	301	90.4	100.0	
Missing	System	32	9.6		
Total		333	100.0		
Kerosene	**-**	**Frequency**	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Yes	89	26.7	29.6	29.6
	No	212	63.7	70.4	100.0
	Total	301	90.4	100.0	
Missing	System	32	9.6		
Total		333	100.0		

About half of all the respondents use firewood as a primary cooking fuel (Table 5.7). The residents have to cut trees in surrounding nearby bushes in order to obtain the firewood. The continuous cutting down and burning of trees emits carbon (CO_2) into the atmosphere which contributes to climate variability and change. Seventy percent (70%) of communities use charcoal and only 7% use gas for cooking as it is the most expensive cooking fuel. Use of charcoal as a fuel contributes to carbon emissions.

5.3.3 Shelter Quality

The shelter quality in these informal settlements is a fusion of traditional and modern houses (UN-HABITAT, 2005). The majority of the structures in the urban informal settlements are built using mud and pole materials which are easily destroyed during extreme weather events. Nyalenda A has the highest percentage (86%) of people living in mud and pole houses (Table 5.8). Obunga has 30% of its residents living in houses which are made of corrugated iron sheets (Table 5.8). Both iron sheets and mud and pole housing are destroyed by flood water in the rainy seasons. The houses made of iron sheet also become inhabitable during extreme heat conditions because the iron sheets absorb a lot of heat from the sun. During the household survey residents mentioned that sometimes flood water reached window level and they would have to evacuate and return to their homes when floods subside. The respondents who live in brick houses are 14%. This shows only a few of the residents can afford to use brick wall material to construct their houses.

Majority of the land in the urban informal settlements has no legal ownership. Sixty one percent of the respondents live on land that they do not own legally (Table 5.9). Thirty-nine percent (39%) of the respondents claimed to have legal ownership of their land, some of them gained it through inheritance. This shows that the communities could have an attachment to live in these hazardous areas due to the fact that they inherited the land from their fore-fathers. Majority of the houses are rentals and they cost from 300-800 Kenya shillings per month for a single room with communal facilities (UN-HABITAT, 2015).

Table 5.8: Urban household main type of building material (%) VI- Vulnerability Index

Name of Informal settlement	Corrugated Iron sheets	Mud and Pole	Brick walls	VI	Criteria of Determination VI
Nyalenda A	2	86	12	3	1. Brick wall materials 0-30% (Low Vulnerability - 1), which is considered least vulnerable as they are the richest group in the area; 2. Corrugated roofing materials between 30-70% have (Medium Vulnerability - 2), 3. Mud and Pole above 70-100% have (High Vulnerability - 3), based on the main type of roofing material in Kisumu city urban informal settlements which are considered most vulnerable as they are the poorest group. 4. Kenya Vision 2030 has placed infrastructure at the top of its list of development agendas and Kenya policies advocates for appropriate roofing products. 5. SDG 11 advocates for making cities resilient, safe and sustainable
Nyalenda B	6	71	23	3	
Manyatta A	8	82	10	3	
Manyatta B	10	75	15	3	
Otonglo	3	78	19	3	
Obunga	35	53	12	3	
Cumulative Total				3	

Table 5.9: Legal Ownership of land and title deeds of the settlements

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	124	37.2	38.9	38.9
	No	195	58.6	61.1	100.0
	Total	319	95.8	100.0	
Missing	System	14	4.2		
Total		333	100.0		

5.3.4 Population Health

In terms of accessibility to clinics, majority of the urban informal settlements (70% to 100% of residents) do not have access to clinics (Table 5.10). This can worsen their public health because if the majority cannot access these facilities it means most residents are not able to access treatment which explains the high mortality rates during flood period.

Table 5.10: Accessibility of health facilities to the urban households Clinics (%) VI-Vulnerability index

Name of Informal Settlement	Yes	No	VI	Criteria for Determination VI
Nyalenda A	8	92	3	1. 0-40 % of the population have access to health facilities (Low Vulnerability – 1) based on their accessibility; 2. 30-70% has minimal access to health facilities (Medium Vulnerability- 2) based on accessibility; 3. 70-100% have no access to health facilities and have (High Vulnerability- 3) 4. The Government of Kenya has addressed the issue of inequalities and poor performance in a number of policy documents of health facilities 5. SDG 5 aims to ensure good health and well-being and end epidemics of TB, Malaria and water borne disease by 2030
Nyalenda B	2	98	3	
Manyatta A	22	78	3	
Manyatta B	35	65	2	
Otonglo	17	83	3	
Obunga	20	80	3	
Cumulative Total			3	

Sixty two percent of the residents reported that they suffer from typhoid during dry periods. Typhoid is a common disease in the area which is associated with severe water shortage and sanitation challenges in the settlements. Twenty eight percent of the residents also mentioned cholera outbreaks as being prominent during dry periods and 31% mentioned diarrhoea (Table5.11). These diseases are also related to overcrowding and low sanitation levels

because of exposure to hazardous waste and inappropriate waste disposal methods which include dumping in nearby bushes or in the Lake Victoria.

Table 5.11: Environmental health problems associated with Dry Spells (%) Criteria for VI-Vulnerability Index

Name of Informal Settlement	Typhoid	Cholera	Amoeba	Dysentery	Diarrhoea	VI	Criteria for Determination VI
Nyalenda, Manyatta, Otonglo & Obunga	62	28	8	0.6	31	2	1. 0-40 % of the population have access to health facilities (Low Vulnerability – 1) based on their accessibility; 2. 30-70% has minimal access to health facilities (Medium Vulnerability- 2) based on accessibility; 3. 70-100% have no access to health facilities and have (High Vulnerability- 3) 4. The Government of Kenya has addressed the issue of inequalities and poor performance in a number of policy documents of health facilities SDG 5 aims to ensure good health and well-being and end epidemics of TB, Malaria and water borne disease by 2030

In rainy seasons, almost all of the residents (97%) were in agreement that malaria is the most prominent disease during flooding (Table 5.12). Poor drainage systems in the area make a conducive environment for mosquito breeding grounds. Malaria, now an endemic in Kisumu, is one of the diseases that is being addressed globally under the sustainable development goals; in particular, under SDG 5 which aims to end malaria by 2030. The residents also mentioned pneumonia (38%) as a common disease, especially affecting children. Measles (22%) was also mentioned by mothers as affecting children during the rainy seasons.

Table 5.12: Environmental health problems associated with flooding (%) VI- vulnerability index

Name of Informal Settlement	Malaria /Fever	Flu	Pneumonia	Measles	VI	Criteria for determining VI
Nyalenda, Manyatta, Otonglo & Obunga	97	41	38	22	3	1. 0-40 % of the population have access to health facilities (Low Vulnerability – 1) based on their accessibility; 2. 30-70% has minimal access to health facilities (Medium Vulnerability- 2) based on accessibility; 3. 70-100% have no access to health facilities and have (High Vulnerability- 3) 4. The Government of Kenya has addressed the issue of inequalities and poor performance in a number of policy documents of health facilities SDG 5 aims to ensure good health and well-being and end epidemics of TB, Malaria and water borne disease by 2030

5.3.5 Age and Gender

The survey data shows that majority of the respondents are youth, falling in the age group of 20-29yrs (Table 5.13). The youth normally move from the rural areas in search of better opportunities in urban areas. Most of the youth in this age group might be in schools or trainings or working casual jobs. Twenty one percent (21%) of the residents are between the ages of 30-39yrs and 13% are between 40-49yrs -these age groups represent the working population along with the 20-29 years of age who are not in school or training (Table 5.13). According to the World Bank in 2016 the percentage of the working population in Kenya is 22.95%.A small working population shows there is a high dependent population which

shows extreme poverty. In the same year the age dependency age ratio (those below 15 years of age and those above 64 years) in Kenya stood at 77.05% (World Bank, 2016). The impact of climate extremes will make the urban poor worse off because majority of Kenya's population are dependants.

Table 5.13: Distribution of households by age (%) VI-Vulnerability index

Age Categories in Years	Frequency	Percentage (%)	Vulnerability Index	Criteria for Determination
Less than 20	34	11	3	1. Dependent population (less than 29yrs) (High vulnerability -3) 2. Dependent population (+50yrs) (Medium vulnerability -2) 3. Working population (30-49yrs) (Low vulnerability- 1) Kenya has total dependency ration of 81.5% Dependent population (UNDESA, 2018)
20-29	142	44	3	
30-39	68	21	2	
40-49	42	13	2	
Above 50	35	11	3	
Total	321	100	3	

The gender ratio of the respondents is 63% women and 37% male population as mentioned in section 4.4. The women were the most respondents since most of their husbands had gone to work and most women are housewives which were found at home during the household survey.

5.3.6 Distribution of household members by level of Education

On educational levels, the survey data showed that about 3% have not received formal education. This percentage comprises village elders who did not acquire any form of education. At least 55% have received primary school education and only 34% had gone up until secondary school (Table 5.14). Most women had reached primary school level and did not proceed to secondary school. Only 6% have gone to college and 2% have gone up until university level (Table 5.14). The respondents are not able to get competitive jobs in Kisumu City because most of them have not reached college or university level. The limited

educational achievements explain why most of the respondents are unemployed or self-employed.

Table 5.14: Distribution of respondents by level of education (%) VI- Vulnerability index

Level of Education reached	Frequency	Percentage (%)	VI	Criteria of determination VI
Primary	183	55	3	1. 0-30% distribution of education reached college or university (Low Vulnerability-1) 2. 30-50 %distribution of education reached in secondary school (Medium vunerability-2) 3. 50-70% distribution of education reached in primary school and no formal of education level reached (High vulnerability -3) SDG 4 ensures inclusive and equitable quality education and promote life learning opportunities for all
Secondary	113	34	2	
College	21	6	1	
University	5	2	1	
No Education	10	3	3	

5.3.7 Summary of Vulnerability

The cumulative vulnerability index of household level is 14 and environmental at 15 and all levels rank in the category "high". This underlies the need for immediate attention to reduce the vulnerability of the Kisumu City urban informal settlement dwellers to climate extremes.

Vulnerability Indicators			
Individual/Household	**Vulnerability index**	**Environmental**	**Vulnerability Index**
Age and Gender	3	Sanitation and Drainage	3
Income	3	Water Supply	3
Energy, cooking & lighting	2	Biophysical Environment and location	3
Shelter Quality	3	Roads and Pathways	3
Level of Education	3	Population Health	3
Total Max	14	**Total Max**	15
Cumulative Vulnerability or Cumulative Exposure (1-6) LOW; (6-12)- MODERATE and (12-18) HIGH			

6.4 Discussion

The results reveal high vulnerability of the Kisumu informal settlement dweller to the impact of climate extremes. The urban poor in Kisumu City are particularly at high risk with recurrent droughts, heavy precipitation and rising temperatures as a result of global climate change (Ofulla, 2016). The climate extremes are accompanied by climate induced disease. The socio-economic vulnerability indicators show that most of the president's health is threatened by climate extremes. According to the IPCC (2007) health risks associated with flooding due to climatic changes in the poor developing countries have been identified. Drought and high temperatures have been also linked to malnutrition especially in urban poor households (Ofulla, 2016). The households mainly experience water-borne disease such as typhoid in relation with dry spells and water-related disease such as malaria during flooding periods. Malaria is now endemic in the Lake Victoria Basin (LVB) region (Wandiga et al, 2010), and is ranked as the major cause of infant mortality and morbidity in most tropical regions of the world (WHO,2010).

As most of the urban poor in Kisumu City live below the poverty line they are not able to afford treatment of these climate induced diseases, as their incomes are very low making them more vulnerable. According to (Cooley et al., 2012) climate induced disease pushes a greater number of the households under the poverty line due to costs incurred during treatment of climate induced disease. The urban poor lack coping capacity to be able to cope with climate variability. Most of their livelihoods are also dependent on water resources and are not sustainable especially when they are affected by extreme weather events. The household's incomes are affected, reducing their standard of living.

The shelter quality of the Kisumu urban informal settlements are mainly constructed using mud and pole materials; but there are others which are constructed from corrugated iron sheets. This is similar to other urban informal settlements, where housing is constructed using poor quality housing materials, located in dangerous sites, and in areas that lack urban infrastructure services (Satterthwaite et al., 2018). All these housing types are vulnerable to climate extremes; their vulnerability is enhanced due to dangerous siting. The IPCC 5th Assessment identifies informal settlements in coastal areas and floodplains as the most vulnerable to climate change. Most of the urban informal settlers in Kisumu live near the lake

shore and they have to relocate especially during flooding period because their houses become uninhabitable when inundated with water. The city of Khulna in Bangladesh faces a similar challenge as it is located in the most vulnerable climatic zone of Bangladesh where they are severely affected by river flooding and water logging (Parvin et al., nd).

Sanitation and drainage is also another major indicator of vulnerability in the Kisumu informal settlements. The residents do not have proper human waste disposal systems. The main type of human waste disposal is the pit latrine which fills up and flows as sewage water during flooding and appears in the resident's houses. According to the results the residents have no appropriate drainage systems and in times of flooding they have to dig trenches to make flood water outlets. Most cities in Africa lack sanitation and drainage systems and this also includes other regions of the global south (Satterthwaite et al., 2018) The United Nations has estimated about 1.6 billion of urban low income nations in the world lacking properly managed sanitation.

Water supply in the urban informal settlements is limited; most of the dwellers survive from illegal connections. The urban poor cut the main pipes of water from main source in order to access water as not everyone can afford to legally connect directly from the main source of KIWASCO water. The use of water from the main source is limited to drinking and cooking only. The WHO (2018) estimates that about 844 million urban low income dwellers in the world lack safe water and therefore they resort to contaminated water because of the costs in access to water. All the vulnerability indicators show high risk of the Kisumu City urban informal settlement dwellers to the impact of climate extremes.

5.4 Conclusion

The urban poor in Kisumu are at high risk of climate extreme events. Both drought and floods bring negative effects to the communities. The effects of climate change also pose a serious challenge to the health of the urban poor. The living conditions make the urban poor more vulnerable as it also affects their well-being. The urban informal settlements are characterised by poor housing, lack adequate water supply, sanitation and drainage. All these factors plus limited income and education make the Kisumu urban informal settlement dwellers vulnerable to climate extremes.

There is urgent need to reduce vulnerability of the urban poor as they are mostly affected by the impacts of climate change. The county government needs to develop adaptation and risk reduction strategies for the urban informal settlement dwellers to avoid unimaginable suffering. The county government also needs to encourage the communities to diversify their livelihoods as they are mostly dependent on water resources.

CHAPTER 6: COPING AND ADAPTIVE CAPACITY OF THE INFORMAL SETTLEMENT DWELLERS TO CLIMATE CHANGE IMPACTS ON WATER RESOURCES

6.5 Introduction

As discussed in chapter 4 and 5, the key vulnerabilities of the slum dwellers are (1) individual/household exposure which includes: age, gender, income, shelter quality and population health and (2) environmental exposure which includes: water supply, sanitation and drainage and roads and pathways. These vulnerability indicators show that the communities are at high risk to climate extremes. Most of the urban informal settlement dwellers have low adaptive capacity for climate variability and change and to all environmental hazards. This makes the urban poor vulnerable to any increased intensity of rainfall or increased disease risk or constraints on food and water supplies. It is very difficult to come up with a pro-poor adaptation strategy if the local government does not recognize the urban poor (Satterthwaite, 2007). The vulnerability of the urban poor to climate change is as a result of poverty. Though this might indicate the weakness of national government to support urban policies systems that ensure preparedness of climate extremes and ensure water infrastructure is in place (Satterthwaite, 2007). This chapter examines the coping and adaptive capacities of the urban slum dwellers. A disaster risk reduction and adaptation framework is therefore designed according to the community responses for actions to build resilience in Kisumu City urban informal settlements.

6.6 Coping strategies

The communities in the urban informal settlements have ways to cope with water shortage. Forty-two percent (42%) of the respondents mentioned that they use water storage containers to counter water availability challenges. The water containers are 20-liter jerry cans they keep in their homes. Forty-seven percent (47%) stated that they extend the water pipes from the main source to their homes although it is expensive, and they might have to seek for loans to do so. Twenty-two percent (22%) of the respondents in Nyalenda stated that to cope with water shortage they established communal water points with the aid of non-governmental organizations, for water storage and to improve water supply at all times (see figure 6.1).

Twenty-five percent (25%) of the people interviewed mentioned that they look for people to drill them boreholes collectively with other community members or dig shallow wells. Three percent (3%) purchase wheel barrows to carry large amounts of water which they store for future use. These results present community efforts in trying to adapt or cope with water shortage. However, the results show that the community are constrained financially and need local government support in terms of making water available in their communities.

Figure 6.1: Communal Water Point in Nyalenda informal settlement

The measures taken in the urban informal settlements to manage flooding are digging trenches as flood water outlets. Eighty percent (80%) of the respondents have dug trenches to create flood water outlets and drainage. Ten percent (10%) of the respondents who live near the Nyamasaria River (within a distance of 10-30meters) have to relocate during flooding. The flood water enters their homes and fills up to window level height, and renders some areas uninhabitable. Twelve percent (12%) use sand bags to prevent flood water entering their houses. One percent (1%) builds gabions to prevent water entering their homes. Kisumu informal settlements have minimal drainage systems. The county government needs to construct a drainage system and flood water outlets in areas prone to flooding.

To adapt to climate extremes the communities in Manyatta area have indigenous knowledge systems for prediction of extreme weather events. These predictions are mostly done by village elders, twenty-three percent (23%) of the respondents mentioned village elders predict drought through their traditional early warning signs (see table 6.1). The signs include: relocation of weaver birds, death of livestock, and appearance of clouds. Seventy seven percent (77%) of the respondents mentioned that some village elders are not able to predict the extreme events. These indigenous knowledge systems need to be explored further in light of adapting to or coping with climatic changes so that they are incorporated in local adaptation strategies (Ayadi, nd).

Table 6.1: Community early warning signs of drought

	Early warning Signs	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very cold in the morning	15	4.5	5.0	5.0
	Children get sick because of nectar	3	0.9	1.0	6.0
	Mist in the morning	1	0.3	0.3	6.3
	Wind blows towards lake	23	6.9	7.6	14.0
	Increased temperatures	3	0.9	1.0	15.0
	Experience floods	1	0.3	0.3	15.3
	Low clouds	4	1.2	1.3	16.6
	Weaver bird relocates	4	1.2	1.3	17.9
	No clouds	3	0.9	1.0	18.9
	Clouds appear very white	1	0.3	0.3	19.3
	Grass disappears	3	0.9	1.0	20.3
	Livestock die	1	0.3	0.3	20.6
	Leaves wither and fall	3	0.9	1.0	21.6
	Mosquitoes and food shortage	1	/0.3	0.3	21.9
	Drizzling of rain	1	0.3	0.3	22.3
	Soil is dry	1	0.3	0.3	22.9
	N/A	232	69.7	77.1	100.0
	Total	301	90.4	100.0	
Missing	System	32	9.6		
Total		333	100.0		

To predict heavy rains the village elders use indigenous knowledge systems by observing low clouds, increase in locusts and frogs (see table 6.1). The role of traditional knowledge systems is to build sound adaptation strategies which suit specific communities and reduce

risk in a changing climate. The communities mainly depend on traditional knowledge systems this is because the communities in the informal settlements have lost trust in the Kenya Meteorology Department early warning alerts.

Table 6.2: Community early warning signs of flooding

	Early warning signs	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Low clouds	12	3.6	4.0	4.0
	Clouds shift from lake to highlands	6	1.8	2.0	6.0
	Increase in locusts, reptiles	4	1.2	1.3	7.3
	Dark clouds	9	2.7	3.0	10.3
	Hot temperature	9	2.7	3.0	13.2
	Windy and cold	12	3.6	4.0	17.2
	Weaver bird relocates	3	0.9	1.0	18.2
	A lot of frogs	2	0.6	0.7	18.9
	Children start getting sick	3	0.9	1.0	19.9
	Certain bird flies	1	0.3	0.3	20.5
	No dust	1	0.3	0.3	20.9
	Wind waves	1	0.3	0.3	21.2
	Very cold a night	1	0.3	0.3	21.5
	Thunder and lightening	2	0.6	0.7	22.2
	N/A	235	70.6	77.8	100.0
	Total	302	90.7	100.0	
Missing	System	31	9.3		
Total		333	100.0		

6.7 Community perspectives on the role of government and institutions

Ninety eight percent (98%) of the respondents stated that the government has not put strategies in place to manage flooding, ensure availability of clean water, and ensure future sustainability of water supplies. Water pipes are not maintained. Most pipes are old and worn out and some are easily damaged which creates entry points for water contamination. Eighty-five percent (85%) of the respondents also noted that the government does not issue early warning before flooding. Ninety-seven percent (97%) also state that the government does not educate or train the community on flood control and management. Ninety-six percent (96%) of the respondents said the government needs to upgrade critical infrastructure for water supply and sanitation. The residents think the government needs to put strategies in places to manage water demand and improve in water and sanitation planning. The key informants

(see appendix B) also urged for training programs for the communities to build awareness in the urban informal settlements on issues regarding climate change.

Ninety nine percent (99%) of the respondents stated that the government has not put strategies in place to manage drought and water scarcity. The government has not maintained water pipes for sustainability of water supply in the future. Eighty-six percent (86%) of the respondents also noted that the government does not issue early warning before dry spells. This could be because Kisumu City is not in the ASAL region. Only 2% state the government has offered education or training for the community on drought. Ninety-seven percent (97%) of the respondents say the government needs to upgrade critical infrastructure for water supply and sanitation. The residents also think the government needs to put strategies in places to manage water demand and improve in water and sanitation planning.

In general, 72% of the respondents think Kisumu County Government has not given support to communities on flooding and drought issues. Fifteen percent (15%) think the county government has given support to communities on drought issues because the communities claim to have been given bags of maize during dry periods. According to the (IPCC, 2007) all urban centres have the potential to have adaptation strategies to reduce risk from impacts of climate change by creating appropriate places for housing, ensuring provision of water, putting infrastructure which is climate resilient. A well governed city always has measures in place to ensure water infrastructure and housing infrastructure is climate resilient, and water systems cope with fluctuations in water supply (IPCC, 2007). Good public health services should be able to cope with climate induced health risk whether it might be due to increased or decreased water supply (Satterthwaite et al., 2007).

6.8 Adaptation and Disaster Risk Reduction Framework

Analysis of rainfall and temperature trends of Kisumu City in chapter 4 shows immediate need to create adaptation and risk reduction measures. Adaptation and disaster risk reduction strategies for sustainable and safe water supplies are crucial in Kisumu City urban informal settlements as extreme weather events prevail which impacts fresh water supplies. Adaptation requires planning since it offers a wide range of benefits. Adaptation planning should be integrated in the existing emergency plans, in water demand and supply planning,

conservation practices, capacity development, infrastructure maintenance, and sustainability goals (EPA, 2015). According to World Bank (2010), an urban water utility adaptation framework should include some strategies to sustain water supply, one of which is to monitor climate change through monitoring the rainfall and water utilities performance, and managing the water resources. The adaptation framework for World Bank (2010) includes: diversification of water sources e.g. building new water storage facilities, using desalinated or recycled water, and using ground water in a sustainable manner without over abstraction. Enhancing storage capacity by building new reservoirs to cope with daily, monthly and yearly water availability is also recommended as an adaptation strategy, coupled with integrated water resources management (World Bank, 2010).

The key informants mentioned some adaptation measures to sustain water supply in the urban informal settlement. The Urban Water Services Provision Officer from Ministry of Water in Kisumu County recommended solar water management systems because of the high costs of electricity which causes power outage due to delayed payments, and prudent management of water systems and financial resources (see appendix B).The Ministry of Environment representative in Kisumu County also recommended (1) strengthening of institutional policy within institutions (2) compliance to water regulations and (3) raising consumer's awareness to sustainable water consumption. The WRA and SANA international representatives indicated that the communities should be included in integrated approaches to water management and formulation of regulatory policies. The Lake Basin South Water Services Board representative also mentioned the need for investment in a new water and sewerage system because the current system was designed for 19% of the current population (see appendix B). There is urgent need to sustain water systems in Kisumu to be able to solve the challenge of clean water shortage.

An adaptation and disaster risk reduction framework has been designed based on the findings presented in this study (Figure 6.2). The major aim of the framework is to reduce risk of the urban slum dwellers to the impact of climate extremes

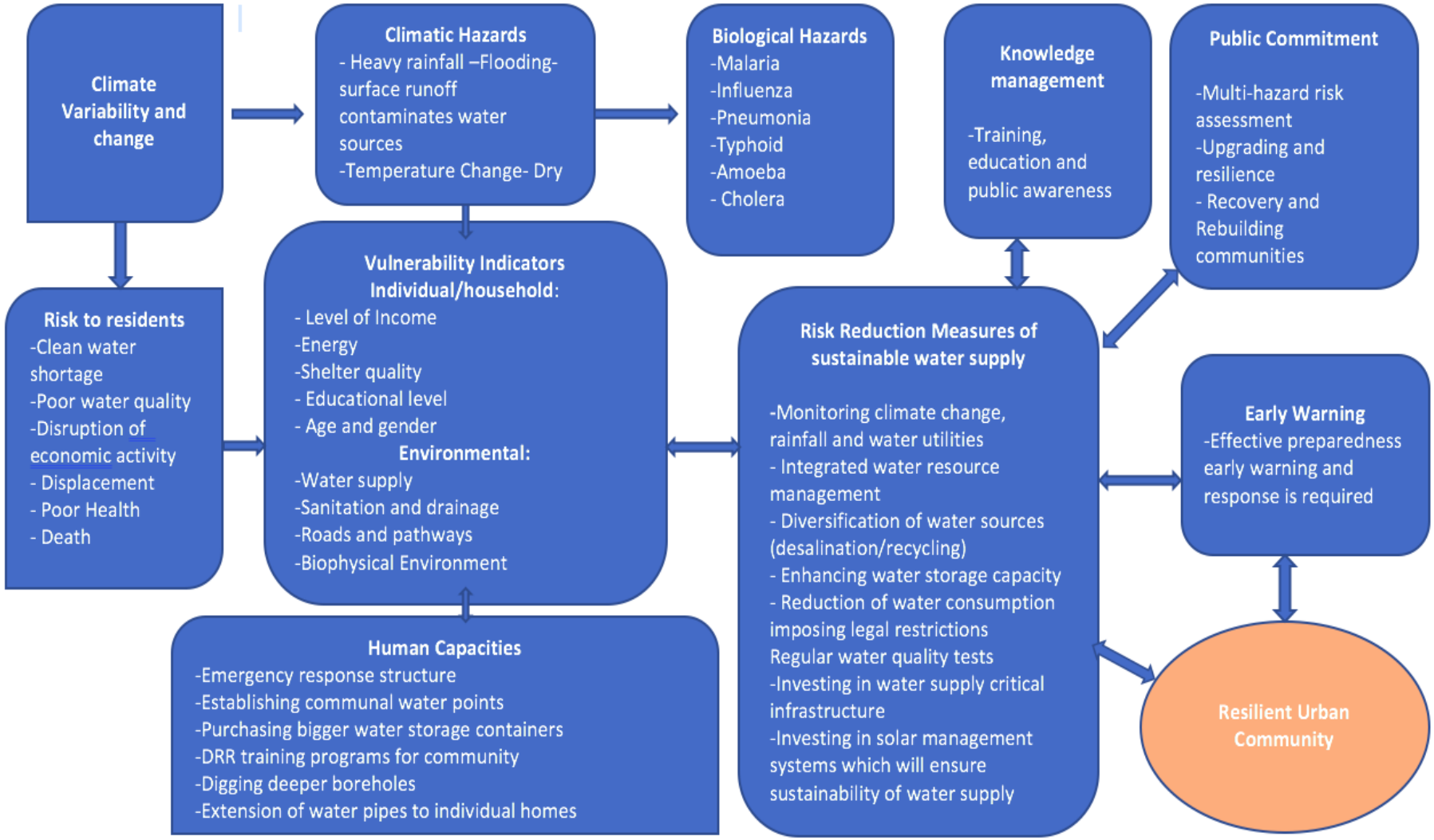

Figure 6.2: Adaptation and Disaster Risk Reduction framework and actions to build resilience in Kisumu City urban informal settlements

Climate change and variability has led to prolonged drought and high incidence of flooding that are accompanied by biological hazards which heighten risk of diseases such as typhoid, cholera and malaria (Figure 6.2). Other risks relate to poor water quality, clean water shortage and death by drowning. The urban informal settlement dwellers are unable to adapt because of their income status and well-being. However, to sustain water supply there is need to invest in critical infrastructure which is climate resilient, enhance water storage capacities and supply capacities, and diversify livelihoods. In terms of human capacity, the communities need to be trained on DRR and have emergency response support structures in place (Figure 6.2). For adaptation strategies to be functional there is need for public commitment, knowledge management, early warning, and application of risk reduction measures. These are discussed further below.

6.1.1 Public Commitment

6.1.1.1 Institutional and Administrative framework

According to the Hyogo and Sendai frameworks, there is need to understand disaster risk and vulnerability in the urban informal settlements based on the exposure of the urban informal settlements communities and their assets; these will help in making effective preparedness plans to respond to climate induced disasters (UNISDR, 2015). Building coordination through local alliances and ensuring that all stakeholder groups in Kisumu City understand disaster risk is crucial (Disaster Risk Management Master Plan Handbook, 2009). Building an administrative institution is useful and contributes to community development in managing disaster risk in Kisumu City urban settlements and understanding the potential hazards and sudden events which require participation of county government decision makers. The administrative institution should include Kisumu City officials and business, government departments, academia and local groups. Lessons learnt through the Hyogo Framework shows that suitable policies and an institutional framework for decision-making can assist in coming up with effective adaptation and disaster risk reduction actions.

6.1.1.2 Multi-hazard Risk Assessment

Updated information on hazards is very important to the Kisumu County Government, local authorities, ministries and non-governmental organizations for the development planning process. This will ensure the information and planning for resilience is available to the locals (World Bank, 2011).

Kisumu City informal settlement residents need to clearly understand their risk to climate induced disasters to enable a meaningful and effective adaptation and risk reduction plan. Risk assessments are essential fundamentals for prioritizing adaptation projects, informed decision making, planning for risk reduction and discovering low to high risk areas for potential interventions. A hazard mapping system of vulnerabilities and the exposure of these communities' assets and coping capacity will give a base for risk assessment.

6.1.1.3 Infrastructure Protection, Upgrading and Resilience

According to the Kisumu County Ministry of Water Urban Provision representative (see Appendix B) the county needs to replace outdated equipment and invest in and maintain critical infrastructure for water supply which is resilient to climate extremes such as flooding and extreme temperatures, adjusted to cope with climate change. These preventive measures will avoid disruption of water supply networks and infrastructure, which can cause adverse health, economic and social consequences. Lifelines such as water supplies, roads, electricity, communication systems, hospitals and emergency services are essential for a society to function during a response to climate induced disaster (UNDP, UNISDR, 2007).

6.1.1.4 Recovery and Rebuilding Communities

After flooding has occurred, or any other climate induced disaster, the needs of the communities should be prioritized for them to be able to recover and design a recovery and response implementation of rebuilding their homes and livelihoods. Almost half of the respondent's livelihoods depend on water resources (see section 4.3). A sound participatory recovery and reconstruction course of action helps the poor communities reactivate themselves, rebuild and restore damaged infrastructure. Empowering communities to rebuild their livelihoods and housing is critical. Reconstruction must be at the forefront after a disaster happens.

6.1.2 Knowledge Development

6.1.2.1 Training, Education and Public Awareness

Training and education programs on disaster risk to flooding and drought should be ensured in the urban informal settlements' communities and in schools. The general public should take part in creating a resilient community in Kisumu City, by getting training, education and public awareness. About 97% of the respondents in the urban informal settlements have not received any form of training on drought and flooding. Schools in Japan, for example, are now educating children as early as nursery school age, on how to react when climate-induced disasters occur (UNISDR Asia and Pacific, 2009).

The entire community must know the type of hazards they are exposed to so that they can take measures to cope with a changing climate. Capacity building, and awareness programmes on adaptation and disaster risk measures are fundamental to enhance community participation in the residents' disaster risk reduction strategies. This will enable the communities to respond to local warnings, which will build trust with the meteorology services, which is currently at a very low level (see section6.2).

6.1.3 Early warning

6.1.3.1 Effective Preparedness, Early Warning and Response

Development of early warning systems, emergency management and preparedness plans are crucial. Preparedness drills are also very important. A well-coordinated emergency response often contributes to resilience and reduces the impact of a climate induced disaster (World Bank, 2011). Early warning systems and preparedness will help ensure that Kisumu City urban informal settlements threatened by hazards can easily cope with the changing climate and reduce stress or damage and loss of life in vulnerable areas. Sustainability of water supplies in a changing climate can be achieved if the community and county authorities understand the significance of preparedness and response.

6.1.4 Application of Risk Reduction Measures

6.1.4.1 Financing and Resources

There is need to assign an appropriately scaled budget to address hazards associated climate extremes in Kisumu City and to provide incentives for pipe extensions and building communal water points for communities and low-income families to invest in reducing the risks they encounter posed by climate change. The Ministry of Water Urban Provision Officer mentioned that there is need for the county to budget for these sudden events to ensure sustainable water supply in the informal settlements (see Appendix B). The county government also should allocate financial resources for adaptation and disaster risk reduction. Resources can come from Kisumu City revenues, national disbursements and allocations to sectoral departments, public-private partnerships and technical cooperation, and from civil society and external organizations (ICLEI, 2011).

6.1.4.2 Protect Vital Facilities: Education and Health

County government needs to assess all-health facilities and schools and upgrade them. There are critical shortages of health facilities in Kisumu City. Almost half of the respondents have no access to clinics and hospitals. Health facilities provide crucial service to the communities and the most vulnerable groups in society. Schools and hospitals are also places of care, development and well-being (Pan American Health Organization, 2008). The facilities play a major role after flooding or dry spell periods where they treat the victims.

6.1.4.3 Building Regulations and Land Use Planning

The county government should enforce building and land use planning regulations. Building codes and regulations ensure that the residents have safe structures to live in. Safe habitable areas, which are not in flood plains, should be identified by the county government for low income slum dwellers. The county government should also institute a slum upgrading programme. The application of building or construction codes and monitoring the land use of the city is a helpful way to reduce vulnerability from climate induced disasters and risk from climate extreme events such as flooding and drought.

6.1.4.4Environmental Protection and Strengthening of Ecosystems

Ecosystems need to be protected to mitigate flooding and other hazards to which Kisumu City slum dwellers are vulnerable to, building on good risk reduction practices. Ecosystems enhance the resilience of the community by strengthening livelihoods and supporting the increased availability and improved quality of drinking water, food supplies and other natural resources (Mekong River Commission for Sustainable Development, 2009). Sustaining the balance between ecosystems and human actions can be a good strategy to reduce risk, and contributes to resilience and sustainability water resources.

6.9 Discussion

Results show that the urban informal settlements in Kisumu City have low adaptive capacity to the impact of climate change posed on water supply, concurring with the observation by Miltin & Sattethwaite (2013) that the urban poor face the largest risk on the impacts posed by climate change. This is because the urban poor communities have limited income to be able to adapt. The communities' efforts to cope with a changing climate include water storage in 20 litre jerry cans and some have contributed to construction of communal water storage and water points so that they can access this water in times of water crises in Nyalenda.

To cope with flooding the urban poor dig trenches as flood water outlets to manage flooding. Some of the urban poor evacuate to schools which are converted to temporary evacuation camps by the county authorities. The urban poor have no money to relocate to safer areas or build resilient homes (Miltin & Sattethwaite, 2013). However, in Mukuru informal settlement the communities, as in Kisumu, dig trenches for flood water outlets (MnU, 2016). In addition, the Mukuru informal settlement dwellers use sand bags to contain flooding, elevate their houses in flood prone areas and stack rocks to prevent flood water from flowing in their homes. According to research done by Miltin & Sattethwaite (2013) in some other urban informal settlements, residents build low walls on their doorways, though these strategies do not necessarily build resilience as there are elevated and new types of risks.

Findings show that Kisumu City urban informal settlements dwellers use traditional early warning systems to predict extreme weather events which are normally done by village elders. The survey revealed that communities in the informal settlements have lost trust in the

Kenya Meteorology Department early warning alerts, because sometimes the predictions are not accurate. Traditional indigenous knowledge is crucial for disaster risk management and environmental conservation (Greinier, 1998). Indigenous knowledge systems have been successfully used in Rajasthan, India to help reduce risk of climatic hazards by building awareness (Pareek, 2011).

The community perception on the role of the government towards climate change issues, is that the county government of Kisumu has not put strategies in place to manage drought and flooding and ensure availability of clean water supply. According to the urban poor communities the county government do not issue early warning before an extreme hazardous event takes place. The IPCC 5th Assessment highlighted that local urban governance does not normally raise awareness or respond to the citizen's pressures towards climate change. Some urban governments have minimal capacity and not willing to engage in climate change issues (Revi et al., 2014).

However as seen in this chapter, adaptation and risk reduction measures are crucial. Adaptation and risk reduction framework was created from the response from the community to be able to reduce the impact of climate extremes to the slum dwellers. The framework includes the public commitment, early warning, knowledge development and application of risk reduction and adaptation measures. The components of the framework are crucial in building resilience in the urban poor communities which UN- HABITAT (2013)notes is compromised by failure of implementing housing policies and development plans.

6.10 Conclusion

The Kisumu City urban poor have very limited adaptive capacity though they have minimal efforts to cope with a changing climate posed on water resources which could be scaled up in order to be beneficial to the surrounding communities. The indigenous knowledge systems play a significant role in climate predictions in the informal settlements.

The Kisumu County Government needs to prioritise adaptation and risk reduction budget allocation to deal with disaster preparedness and response. The county government officials need to be trained on DRR and CCA failure to do this will leave most of the urban informal settlements dwellers will suffer severe consequences.

CHAPTER 7: SYNTHESIS AND DISSCUSSION

6.11 Synthesis

The overall objective of the research was to work with the communities to develop effective disaster risk reduction and climate change adaptation strategies, to reduce vulnerability of urban informal settlement dwellers to climate extremes that impact safe water supply which have been addressed in the previous chapter. Reduction of potential failure of water supply and sanitation systems will make the urban informal settlement community more resilient. "*A 'Resilient City' is prepared to absorb and recover from any shock or stress while maintaining its essential functions, structures, and identity, as well as adapting and thriving in the face of continual change"* (ICLEI, 2015). The water and sanitation systems are vulnerable to flooding and drought and the goal is for urban planners to understand all the water systems and address all the deficiencies.

To be able to archive the overall objective, the impacts of climate extremes on water supply, quality and use were identified. It is important to determine the impacts of climate change in order to understand how it will affect our future generations with various regions in the world facing water challenges today (UNESCO-WWAP, 2009). This will also enable adaptation commitments by the government, private sector and the general public. Water security can be enhanced through implementation of policies that are sensitive to the needs of vulnerable communities, strengthening institutions, and ensuring investments in climate resilient water infrastructure. According to the UN Water Assessment Programme, "*Water is the primary medium through which climate change impacts the earth's ecosystem and people.* "Identifying the impacts of climate extremes will also help in archiving proper management of water resources and being able to achieve socio-economic development through sustainable goal 6 which encourages integrated water management systems, improvement in water quality and access to water by 2030. However, it is crucial to measure the impact of climate change to sustain water resources for future generations.

Following determination of impact of the climate extremes, a vulnerability assessment was done to determine the impacts of extreme weather events on the most vulnerable urban poor. Vulnerability indicators were identified which were classified according to environmental

and individual/ household level. The importance of characterizing vulnerability is that it helps us to know how the communities are susceptible to the impacts of climate extremes, and shows the capacity to which a community can adapt to a changing climate (WRI, 2014). This process is the centre of the climate change adaptation process and decision making (CALCC, 2014).

Vulnerability assessment is crucial in responding to climate risk or managing future climate risk (Klein et al., nd). The climate change adaptation process involves managing risk posed by climate variability. Characterisation of the human populations' sensitivity to climate helps us to come up with strategies for adaptation for key vulnerabilities and to monitor climatic stresses (Klein et al., nd). One of the major challenges today for climate change is addressing the issues of vulnerability of the urban poor to extreme weather events such as flooding and drought (UN Water, nd). Many regions of the world have suffered seasonal scarcity of water or from seasonal rainfall which results in flooding like in Kisumu City (UNESCO-WWAP, 2009). This shows urgent need to build resilience in the poor communities.

After assessing the vulnerability of the informal settlement dwellers next was to know the coping and adaptive capacities of the informal settlements posed by the risk of climate extremes. Knowledge of existing coping mechanisms in the communities could help come up with sound adaptation strategies. The urban poor have low adaptive capacity in the Kisumu informal settlements. Their coping strategies to deal with water shortage include storage of water in containers and establishment of community water points in Nyalenda. The establishment of the water points could be replicated in all the other informal settlements and help sustain water supplies. It is important to understand the adaptive capacity of a community and how to improve adaptive capacity, for communities to be able to able to buffer themselves from climatic stresses. The identified community coping and adaptive capacities could be scaled up to assist the urban poor.

Finally, the last objective was to work with communities to develop adaptation and risk reduction strategies to adverse climate impacts on portable water supply. After identifying the impacts of climate extremes, assessing vulnerability and identifying the coping and adaptive capacities, it was important to work with communities to come up with adaptation strategies. Communities need to understand the issues which are affecting them and have the

ability to design their own solutions (Riedy, nd). An adaptation and disaster risk reduction framework was created based on the communities' responses in order to build resilience in the urban informal settlements.

6.12 Discussion

Over the past decade, the climate has been changing globally, impacting temperature and precipitation and altering water balance in different regions of the world (UNEP, 2009). It is evident that temperatures have continued to rise in the world which has significantly impacted fresh water supply and had devastating effects on water resources (Grace Communications Foundation, 2018). Global warming has also enhanced the magnitude and frequency of extreme climate events – droughts and floods – which are also linked to climate sensitive diseases, as has been established in Kisumu's informal settlements. The results of the research have also shown how climate extremes negatively impacts water supply systems in Kisumu City, and that the water quality and supply is compromised especially during flooding period. The water quality is also affected in dry seasons and the supply is greatly affected during such periods. Climate related diseases (typhoid, cholera) were also found to be associated with the poor sanitation conditions in the area. Another prevailing disease was malaria in the wet season.

These climatic impacts have been also found in other parts of the world. Moldova, for example, is experiencing a great challenge from the impacts of climate change on its water resources, water supply and sanitation systems. The main problem from Moldova starts with increased or decreased intensity of rainfall (Martoussevitau et al., 2013). Increased amount rainfall results in poor water quality, increased flood frequency and rising ground water levels. The impact in terms of water and sanitation are damaged water supply and sanitation systems, and increased contamination of ground water from flooding of sanitation facilities. Similar to Kisumu City, decreased amount of rainfall in Moldova results in deterioration of water quality, failing ground water levels and low surface water flows (Martoussevitau et al., 2013). The impact of decreased rainfall results in WASH challenges and salinity of groundwater which affects water supply. However, Moldova Vison 2030 aims to build

resilience of water supply and sanitation in light of climate change by improving water supply and sanitation planning.

The individual/household and environmental vulnerability indices of the urban informal settlement dwellers in Kisumu show high risk of the communities to climate extremes. This is based on the vulnerability indicators which include: age and gender, level of education, shelter quality, income, public health, water supply and sanitation and drainage. All these vulnerability indicators show the low adaptive capacity of the communities in the urban informal settlements. It calls for the Kenya Government to pay particular attention to the urban poor who are at high risk to the impact of climate extreme conditions, as they are the most vulnerable group.

Dhaka slums dwellers also face similar challenges like Kisumu City urban informal settlement dwellers. The International Centre of Climate Change and Development in Bangladesh in 2015was lobbying for the Bangladesh government to formulate policies to improve water and sanitation conditions in the Dhaka slums, by coordinating NGOs activities. The Dhalpur and Beguntila slums in particular have been facing water supply shortage because of poor services and delivery offered by The Dhaka Water and Sewerage Authority (The Daily Star Bangladesh, 2015). The major challenges of the Dhaka slums include climate hazards such as heat waves, water logging accompanied by poor sanitation and poor water services from the national government which have also resulted in water-borne disease such as diarrhoea, skin infection, cholera and pneumonia (Yasmin, 2016).

According to the results of the research in Kisumu, majority of the urban informal settlement dwellers have low adaptive capacity. The residents are constrained by low incomes and hence cannot buffer themselves effectively against climatic hazards. Consequently, many move from flooded areas to evacuation camps which are normally set up in schools, that area a distance away from the informal settlements. The poor cannot afford adaptation technologies and improved building materials (IHC, 2011). The exposure of climate related risk has grown in the urban areas in particular because of the local government failure to expand or upgrade infrastructure and to implement building standards (UNISDR, 2011).

The biggest challenge in urban areas is adaptation and the national governments have to put this as a priority in its plans (UN-WWAP, 2009). The adaptation plans should reduce risk and protect water ecosystems. The governments should also have forward planning for adaptation strategies on the impacts of climate change on water supply. The ability to respond to climate change impacts will build city resilience to be able to adapt from climate related risk of flooding and drought (UN-WWAP, 2009). Working with communities to build risk reduction strategies and adaptation is very important because the communities know exactly the type of challenges they face. Effective adaptation has to involve the community. Sustainability of water supply systems should be given a high priority for the future especially for the urban poor (IHC, 2011). Many cities will have to prioritise the urban informal settlements in terms of adapting to climate change. This will mean cities will have to invest in critical infrastructure which is climate resilient and review land use planning and regulation (IHC, 2011). Failure for cities to adapt to climate change will result in national losses and countries will fail to achieve sustainable development.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

6.13 Conclusions

To determine the impacts of climate extremes on water supply, quality and use, rainfall and temperature times' series analysis was done. Results show inter-annual variability of rainfall (1987 – 2016), which resulted to drought, and flooding, and temperature patterns (1987-2016) which are warming. Majority of the respondents acknowledged that both flooding and drought impact clean water supply, quality and more than half of the respondents have to use alternative sources of water. Climate extremes continue to pose severe impacts on water supply, rainfall and temperature projections still remain uncertain, and there is an urgent need of adaptation strategies to sustain water supply. The annual total rainfall shows an increasing trend from 1987-2016 though the trend was not statistically significant. The annual mean maximum and minimum temperatures also show an increasing trend from 1987- 2016, but minimum temperatures (Tmin) were rising faster than the maximum temperatures (Tmax) with a rate of 0.03% per year. Based on limited observational research done by practitioners the simulated diurnal cycle for precipitation over the Lake Victoria Basin has been consistent in terms of frequency and amount. Other researchers conclude that climate change will have a minor impact beyond 2030 in terms of water supply and most of the impact will be felt after 2050 as seen in the GCM simulations. The rainfall and temperature projections still remain uncertain, while climate change continues to pose severe impacts on water supply. Kisumu City urban informal settlements dwellers are highly affected by flooding and drought and failure to adapt to a changing climate will leave an enormous number of urban informal settlement residents in extreme poverty.

Vulnerability of the Kisumu City slum dwellers to the impact of climate change was characterized. The outcome of this research shows that Kisumu City urban informal settlement dwellers are highly vulnerable to climate induced hazards such as drought and flooding which are accompanied by climate-sensitive water-borne diseases. The informal settlements in Kisumu City are located in low lying areas, and some of the settlements are along river banks, enhancing risk to flooding relative to other locations. The results also show a serious shortage of social amenities and basic services in Kisumu's informal

settlements with an alarming deficit in clean water supply, access to health facilities, proper sanitation systems (which poses serious challenges like water contamination and exposure to contagious diseases), and proper solid waste management. Livelihoods of the urban poor are susceptible to climate change impacts, and incomes are too low to enable them effectively buffer against climate related impacts on their own. Urban informal settlements dwellers often face significant impacts of climate change which have severe consequences to livelihoods, human health and assets (World Bank, 2011).

The assessment of the coping and adaptive capacity of the informal settlement dwellers to risks posed by climate change shows that the urban informal settlements in Kisumu City have low adaptive capacity to the impact of climate change posed on water supply. This is because the urban poor communities have limited income to be able to adapt. To cope with the changing climate, the communities have adopted a number of strategies, including purchasing water storage containers, establishing communal water points with the help of local NGOs, taking loans to extend water pipes to their homes (only a few because of cost), and digging shallow wells to access water. The limited finances in the communities still remain a big challenge to access potable water. The indigenous knowledge systems have been found to play a significant role in climate predictions in the informal settlements. However, the government has provided minimal support to the slum dwellers to manage drought and flooding. The government has not sensitized the community about drought and flooding issues nor informed or trained the communities on how to respond to climate induced disasters. The Kisumu County Government needs to prioritise adaptation and risk reduction budget allocation to deal with disaster preparedness and response. The county government officials need to be trained on DRR and CCA; failure to do this will leave most of the urban informal settlements dwellers to suffer severe consequences of climate change.

The overall objective of the research was to develop effective DRR and CCA strategies to reduce vulnerability of the urban slum dwellers to climate extremes that impact on water supply. This research unveiled weak urban governance in the city because the national and county government have overlooked improving the urban informal settlements and providing minimum basic services which has led to suffering in the urban informal city dwellers. Several policy and legal frameworks exist at national level that have emphasis on climate

change and on the issues in informal settlements; these can be applied in Kisumu City but there is still a challenge in implementation of these policies and the need for the Kisumu County Government to downscale these national policies and make the policies context specific and action plans applicable to the county needs as it addresses the challenges in Kisumu City urban informal settlements. The Kenya government and UN-Habitat development plan for the urban informal settlements upgrading is a good gesture which does not include investing in the improvement of living conditions and putting the settlements into consideration.

The findings of this research are useful to policymakers and other stakeholders as they can be used to formulate both effective adaptation strategies which are context specific and downscaled workable policies that can used to build climate change resilience in the urban informal settlements of Kisumu City. They can also be applied to addressing the environmental and social challenges in urban informal settlements and help reverse and eventually eliminate the processes of discrimination, exploitation and exclusion of urban informal residents.

6.14 Recommendations

Based on the results findings some recommendations are listed below in order to build resilience to the impact of climate extremes on water supply. The following measures are recommended:

- The county government needs to invest water supply critical infrastructure which is climate resilient. Old worn out infrastructure and pumping plants need to be rehabilitated. The county government needs to invest in solar water management systems which will ensure sustainability of water supply since they incur high costs in using electricity to generate the water and delayed payments cause a disruption in water supply.

- The county government needs to monitor climate change; rainfall, water utilities and water resources. an integrated water resource management should be in place which consists of various stakeholders. Diversification of water sources; building new storage facilities, desalination of water/recycling is other options to deal with water shortage. Reduction of water consumption, Imposing legal restrictions to educational campaigns.

Enhancing storage capacity; building new reservoirs to be able to cater for daily, monthly or seasonal water availability will improve access to health facilities.

- During dry spells the communities can invest in community water points and invest in large water storage containers which they can collect water during the rainy seasons. The community can also start planting drought resistant crops. There is need to diversify livelihoods in the Kisumu City urban informal settlements as most of their livelihoods are dependent on water resources.

- There is need for review of policies together with their implementation strategy; implementation of policies is a major challenge as policies exist with emphasis on climate change.
- Future research work for climate change in urban informal settlements should have focused on mitigation this would encourage more resilience in urban cities. Gaps in implementation of national polices on climate change in urban informal settlements on a county level should be another area of interest in terms of research as existing policies are in place but implementation still remains a major challenge.

REFERENCES

Agong, S., Odino, P., Wanga, J. (2012). A Baseline Survey on Governance, Policies and Knowledge of Urban Sustainbility in the Kisumu Local Interaction Platform. Mistra urban futures. Available from:https://www.mistraurbanfutures.org/sites/mistraurbanfutures.org/files/a_baseline_survey_on_governance_policies_and_knowledge_of_urban_sustainability_in_the_kisumu_local_interaction_platform_gaps.pdf. (Accessed 4 September 2016).

Apsan, A., Walker, J., & Butcher, S. (2013). Participatory Informal Settlement Upgrading andWell-Being In Kisumu,Kenya. Available from: https://www.bartlett.ucl.ac.uk/ dpu/documents/ SDP _Kisumu _report. (Accessed 4 September 2016).

Adger, N., &Aggarwal, P.(2007) Climate Change 2007: Impacts, Adaptation and Vulnerability: Summary for Policy Makers, Working Group II Contribution to the Intergovernmental Panel onClimate Change; Fourth AssessmentReport, IPCC Secretariat, Available from: http://www.afd.fr/webdav/site/afd/shared/PUBLICATIONS/RECHERCHE/ Scientifiques/Serie-grise/Serie-Grise-Understanding-Assessment-Reduction-Vulnerability.pdf (Accessed 8 September 2016).

ADB (2014). Urban Climate Change Resilience. African Development Bank. Available from: https://www.adb.org/sites/default/files/publication/149164/urban-climate-change-resilience-synopsis.pdf (Accessed 9 November 2016).

Aloysius, B. (2012). Floods of fury in Nigerian cities. Journal of Sustainable Development, Vol 5, No7,p.69- 79.

ASDSP (2016). Agriculture Sector Development Support Kisumu County. Available from:http://www.asdsp.co.ke/index.php/kisumu-county(Accessed 17 November 2016).

ACCCRN (2013). Asian Cities Climate Change Resilience Network(ACCCRN) City Projects, The Rockefeller Foundation Asia Office. Available from: https://www.rockefellerfoundation.org/our-work/initiatives/asian-cities-climate-change-resilience-network/ (Accessed 18 November 2016).

ARGOSS (2001). Guidelines for Assessing Risk to Groundwater from On-Site Sanitation, Commissioned report,British Geological Survey. Wallingford, UK.

Bartram, J. and Cairncross, S. (2010). Hygiene, sanitation, and water: for- gotten foundations of health.Available from:http://researchonline.lshtm.ac.uk/2112/1/Hygiene-sanitation-and-water.PDF (Accessed 10 May 2016).

Butunyi, C. (2009). Policy planned on rainwater, *Daily Nation, Provincial news* 6 November, p.34.

Bagewadi, P. and Mukherji, D. (2017). Calculating Disaster Risk Index (DRI) for Greater Mumbai by Hazard Risk and Vulnerability Analysis (HRVA)using GIS. Available from: http://ijetsr.com/images/short_pdf/1507298445_101-107-cdac860-ijetsr.pdf (Accessed 2 Sep. 2018).

Cardona, O.D., M.K. van Aalst, J.,Birkmann, M., Fordham, G., McGregor, R., Perez, R.S.,&Sinh,B.(2012). Determinants of risk: exposure and vulnerability. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-108.

Chepkoech, A. (2017). Kisumu braces for water rationing as key sources dry up, *Business daily*, 27 January, p.11.

Cronin, A., Hoadley, A., Gibson, J., Breslin, N., KouontoKomou, F., Haldin, L., &Pedley, S. (2007).Urbanization effects on groundwater chemical quality J. Water Health, Vol 5, p. 441–454.

Conway, D. (2002). Extreme rainfall events and lake level changes in East Africa: recent events and historicalprecedents. In: Odada EO, Olago D (eds) The East African Great Lakes: limnology, palaeolimnology and biodiversity. Kluwer Academic Publ., Dordrecht, p. 64–92.

Dacosta, V. &Ominde, S. (1973). Soil and Land Use Survey. Available from: https://library.wur.nl/isric/fulltext/isricu _i00002727_001.09.pdf (Accessed 11 November 2016).

Daily Nation. (2009). 'Four die as rains pound west Kenya', *Daily nation*, 23 September, p.16.

Dickson, E., Otor, S., and Afullo, A. (2018). Effect of Household Water-User Preference on the Sustainable Supply of Safe Water in Obunga Slums of Kisumu Municipality, Kenya. Available from:http://irlibrary.ku.ac.ke/bitstream/handle/123456789/18455/Effect%20of%20Household%20WaterUser%20Preference.....pdf?sequence=1 (Accessed 30 Jul. 2018).

Disaster Risk Management Master Plan. (2009), Disaster Risk Reduction in Greater Mumbai Project MCGM-EMI Collaborative Project. Vol140. Available from http://emi-megacities.org/drmmp_handbook.pdf. (Accessed 12 November 2016).

Dodman, D., Diep, L. and Colenbrander, S. (2017). Making the case for the nexus between resilience and Resource efficiency at the city scale. *International Journal of Urban Sustainable Development*, 9(2), pp.97-106.

Dodman, D. (2017). African Urbanisation and Urbanism: Implications for risk accumulation and reduction. Availablefrom:https://www.researchgate.net/publication/318544528_African_Urbanisation_andUrbanism_Implications_for_risk_accumulation_and_reduction (Accessed 16 December 2017).

FAO/ OEDC (2012). Building resilience for adaptation to climate change in the agriculture sector. Available from:http://www.fao.org/docrep/017/i3084e/i3084e.pdf (Accessed 13 November 2016).

Foeken, D., Ching Chung, H., Mutune, T., &Owuor, S. (2013). Urban water interventions and livelihoods in low-Income neighbourhoods in Kisumu, Kenya. Profiles.uonbi.ac.ke. Available from: https://profiles.uonbi.ac.ke/samowuor/files/2013_asc_working_paper_112.pdf (Accessed 15November 2017).

Gelder, F., Dida, G., Ouma, C. and Owuor, P. (2016). Effects of regional climate variability on theprevalence of diseases and their economic impacts on households in the Lake. Available from: https://repository.maseno.ac.ke/bitstream/handle/123456789/286/Effects-of-regional-climate-variability-on-the-prevalence-of-diseases-and-their-economic-impacts-on-households-in-the-Lake-Victoria-basin-of-Western-Kenya.pdf?sequence=1&isAllowed=y (Accessed 4 July 2018).

Government of Kenya, (2013). First CountyIntegrated Development Plan 2013 - 2017.Available from: http://cog.go.ke/images/stories/CIDPs/Kisumu.pdfJ. Bartram, S. Cairncross 2010, Hygiene, sanitation, and water: forgotten foundations of healthPLoS Med, 7 (11) (2010), p. e1000367 (Accessed 5 September 2016).

Hardroy, J. and Pandiella, G. (2009). Urban poverty and vulnerability to climate change in Latin America. Available from: http://journals.sagepub.com/doi/abs/10.1177/0956247809103019 (Accessed 8 July 2016).

Grönwall, J., Mulenga, M., McGranahan, G. (nd). Groundwater, Self-Supply and Poor Urban Dwellers: A Review with Case Studies of Bangalore and Lusaka; International Institute for Environment, working paper, p.87.

Hilhorst, D &Bankoff, G. (2004). *Mapping Vulnerability: Disasters, Development and People*, Earthscan, London128-44 pp.

Howard, J., Peel, M., Finlayson, M., McMahon, T. (1983). General Climatology, 4th ed. "Updated World Map of the Köppen-Geiger Climate Classification," Hydrology and Earth System Sciences, 11:1633–44 .

ICLEI. (2011). Financing a Resilient city, Available from:http://www.environmental-finance.com download.php? files/pdf/4e1c155b960f6/Report-Financing_Resilient_City-Final.pdf (Accessed 26 June 2011).

ICLEI (2016). *Resilient Cities Report 2016*. Available from: cities/files/Resilient_Cities_2016/Documents/Resilient _Cities_2016_Report.pdf (Accessed 30 June 2017).

Indeje, M., Semazzi, F., and Ogallo, L. J. (2000) EÑSO signals in East African rainfall seasons. Int J Climate Vol 2019–26.

IPCC (2007). Climate Change: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change . Cambridge University Press, Cambridge, UK, p. 976.

IPCC (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. Special Report of the Intergovernmental Panel on Climate Change (IPCC)., IPCC Secretariat, Geneva, p. 582.

Kenya National Bureau of Statistics (KNBS) and Society for International Development (SID) (2013). '*Exploring Kenya's Inequality: Pulling Apart or Pooling Together?' - Kenya National Bureau of Statistics*. [online] Kenya National Bureau of Statistics. Available at: https://www.knbs.or.ke/exploring-kenya-s-inequality-pulling-apart-or-pooling-together/?option=com_phocadownload&view=category&id=114:exploring-kenya-s-inequality&Itemid=599 [Accessed 13 Nov. 2018].

Lepers, J.P., Deloron, P., Fontenille, D., and Coulanges, P. (1988). Reappearance of falciparum malaria in Central Highland Plateaux of Madagascar. Lancet. Vol 12, p585–586.

Lukallo, R. & Okello, R. (1998). 'Tragi-comedy of flooded plains and thirsty land', *Daily Nation*, 8 June, p.21.

Martens, P., Kovats, R.S., Nijhof, S., de Vries, P., Livermore M.T.J., Bradley, D.J., Cox, J., and McMichael,A.J. (1999). Climate change and future populations at risk of malaria. Glob Environ Change. Vol 9, p. S89– S107.

Mekong River Commission for Sustainable Development. (2009). Manual on flood preparedness program for provincial and district level authorities in the Lower Mekong Basin countries. Available from: http://www.preventionweb.net/english/professional/publications/v.php? id=13076. (Accessed 21 June 2017)

Mitlin, D. and Satterthwaite, D. (2013). *Urban Poverty in the Global South*. [online] Google Books. Availablefrom:https://books.google.co.ke/books?id=GYdeN dKrp8sC&printsec=frontcover#v= onepage&q&f=false (Accessed 4 July 2018).

MnU (2016). Research, Analysis of Climate Resilience Options for Nairobi Slums and Informal Settlements.Availablefrom:http://majinaufanisi.org/attachments/article/11 /Nairobi%20Informa l%20Settlements_CC_Final%20Report_22Apr2016%20(1).pdf (Accessed 5 Sep. 2017).

Mukheibir, P. and Ziervogel, G. (2007). Developing a Municipal Adaptation Plan (MAP) for climate change: the city of Cape TownAvailable from: https://www.google.com/search? client=safari&rls =en&q= Mukheibir+and+Ziervogel,+2007&ie=UTF-8&oe=UTF-8 (Accessed 17 July 2017).

Muller, M. (2007). Adapting to climate change. *Environment and Urbanization*, 19(1), pp.99-113.

Nace, T. (2018). Mad Max Scenario: Cape Town will run out of water in just 90 days. Available from: https://www.forbes.com/sites/trevornace/2018/01/18/mad-max-scenario-cape-town-run-out-water-90-days/1#5beec42f6fea (Accessed 10 July 2018).

Nicholson, S. E. (1996). A review of climate dynamics and climate variability in Eastern Africa. In: The Limnology, Climatology and Paleoclimatology of East African Lakes. Gordon and Breach publishers. Amsterdam.p. 25-56.

NOAA (2018). The Impact of Weather and Climate Extremes on Air and Water Quality National Centers For Environmental Information (NCEI) formerly known as National Climatic Data Center (NCDC).Available from:https://www.ncdc.noaa.gov/news/impact-weather-and-climate-extremes-air-and-water-quality (Accessed 3 Aug. 2018).

Ogallo, L. (1989). The spatial and temporal patterns of the East African rainfall derived from principal Components analysis. Int J Climate Vol 9, p.145–167.

Okayo, J., Odera, P., &Omuterema, S. (2015). Socio-economic characteristics of the community that determine ability to uptake precautionary measures to mitigate flood disaster in Kano Plains, Kisumu County, Kenya. geoenvironmental-disasters.springeropen.com. Available from:https://geoenvironmental-disasters.springeropen.com/articles/10.1186/s40677-015-0034-5 (Accessed 17 November 2016).

Okotto, J., Price, H., Wright, J., &Pedley, S. (2015). Socio-economic aspects of domestic ground water Consumption ,vending and use in Kisumu, Kenya. Sciencedirect.com. Available from:http://www.sciencedirect.com/science/article/pii/S0143622815000405 (Accessed 8 September 2016).

Olago, D., Marshall, M., Wandiga, O., (2007). Climatic, Socio-economic, and Health Factors Affecting Human Vulnerability to Cholera in the Lake Victoria Basin.East Africa. Royal Swedish Academy of SciencesAmbio Vol. 36, No 4, p. 350-358.

Ong'Or, B. T. I., &Long-Cang, S. (2007). "Water supply crisis and mitigation options in Kisumu City, Kenya" Water Resources Development, Vol 23 (3), p.485-500.

Otieno, C. (1994). "Fish deaths due to climate change", *Daily Nation*, 2 June, p.34.

Pareek, A. and Trivedi, P. (2011). Cultural values and indigenous knowledge of climate change and Disaster prediction in Rajasthan, India. [online] Pdfs.semanticscholar.org. Available from: https://pdfs.semanticscholar.org/8e03/51e31a8a85c1fc25378df3d496a5c4db9c42.pdf (Accessed 3 Jul. 2018).

Parry, J., Echeverria, D., Dekens, J. and Maitima, j. (2012). Climate Risks, Vulnerability and Governance

in Kenya: A review. Available from: https://www.iisd.org/pdf/2013/climate_risks_kenya.pdf (Accessed 5 Aug. 2018).

Pamojatrust. (2013). Pamoja Trust - Manyatta, Kisumu. Available from: http://www.pamojatrust.org/ index.php?option=com_k2&view=item&id=6:manyatta-kisumu&Itemid=288(Accessed8 September 2016).

Palmer, M. A., Liermann, C., Nilsson, C., Flörke, M., Alcamo, J., Lake, P. S. Bonds, N. (2008), Climate change and the world's river basins: Anticipating management options, Frontiers Ecol. Environ London, UK, Vol 6, (2),p 81-89.

Philip, D. &Rayhan, I. (2004). Vulnerability and Poverty: What are the causes and how are they related. http://www.zef.de/.Availablefrom;http://www.zef.de/fileadmin/downloads/forum/docprog/Termpapers/ 2004_3a_Philip_Rayan.pdf (Accessed 2 November 2016).

Philip, S. & Stevens, L. (2013). Delivering Water, Sanitation and Hygiene Services in anUncertain Environment; Multiple benefits of improved groundwater for low-income urban communities in Kisumu, Proceedings of the 36th WEDC International Conference, Briefing Paper 1828.Loughborough University. Nakuru, Kenya. p 6.

Practical Action (2013). *Participatory Informal Settlement Upgrading and Well-Being in Kisumu, Kenya*. Availablefrom:https://www.ucl.ac.uk/bartlett/development/sites/bartlett/files/sd p_kisumu_report.pdf (Accessed 4 June 2016).

Revi, A., Satterthwaite, D., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R., Pelling, M., Roberts, D., & Solecki, W.(2014). Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. p.535-612.
.

Reuters (2018). *Kenya: Floods - Mar 2018*. [online] ReliefWeb. Available at: https://reliefweb.int/disaster/ff-2018-000030-ken [Accessed 22 Nov. 2018].

SANBI (2014). Long-term Development and Adaptation Scenarios under future climates in SouthAfrica. Availablefrom:https://www.sanbi.org/wp-content/uploads/2018/03/adaptation-scenario-planning.pdf (Accessed 29 September. 2018).

Satterthwaite, D., Huq, S., Pelling, M., Reid, H., and Lankao, P.R. (2007). Adapting to Climate Change in Urban Areas: The possibilities and constraints in low and middle-income nations, Human Settlements Discussion Paper Series, Theme: Climate Change and Cities 1, IIED. Available from: http://www.iied.org/HS/topics/accc.html (Accessed 11Novemeber 2017)

Satterthwaite, D. (2008). Climate Change and Urbanization: Effects and Implications for Urban Governance.Available from:http://www.un.org/esa/population/meetings /EGM_PopDist/P16 _Sa tterthwaite.pdf (Accessed3 September 2016).

Satterthwaite, D., Archer, D., Colenbrander, S., Dodman, D., Hardoy, J. and Patel, S. (2018). Responding to climate change in cities and in their informal settlements and economies. Available from: https://citiesipcc.org/wp-content/uploads/2018/03 /Informality-background-paper-for-IPCC-Cities.pdf (Accessed 10 July 2018).

SEI (2009). Economics of Climate Change Kenya. Available from**:** https://www.seiinternational .org/mediamanager/documents/Publications/Climate- mitigation -adaptation/kenya-climatechange.pdf(Accessed15 November2016).

Seeds of gold team. (2017). 'Farmers adopt coping strategies as dry spell hits crops and livestock', *Saturday Nation*, 21 January, p.30.

Sharma, U. and Patwardhan, A. (2008). Methodology for identifying vulnerability hotspots to tropical cyclonehazard in India. Available from:m https://www.researchgate.net/publication/225560668 _Methodology_ for_identifying_vulnerability_hotspots_to_tropical_cyclone_hazard_in_India (Accessed 3 February 2017).

Shaw, R. (2016). Community-Based Disaster Risk Reduction. Available from:http://naturalhazardscience. oxfordre.com. (Accessed 17 June 2017).

Shimonaka, K. (ed.) (1984) Grand World Atlas. Heibon-sha, Tokyo. p. 273. Available from: http://www.kisumu.co.uk/Geography.htm (Accessed 6 December 2016).

SMEC, & IID. (2006). Local government Land Use Planning and Risk Mitigation. Available from: http://www.royalcommission.vic.gov.au/getdoc/5b3b5e46-44bb-483d-8aa3-a635ee6e9081/TEN.212.001.0001. (Accessed 27 June 2017).

Smit, B. and Wandel, J. (2006). Adaptation, Adaptive Capacity and Vulnerability | Ecological Resilience | ClimateResilience. Available from:https://www.scribd.com/document/270878897/Adaptation - Adaptive -Capacity-and-Vulnerability-Barry-Smit-Johanna-Wandel-2006 (Accessed 6 June 2017).

Terumoto, K. (2006). A Better Integrated Management of Disaster Risks: Toward Resilient Society to Emerging Disaster Risks in Mega-cities. Terra Scientific Publishing Company Tokyo . p. 165–176.

The Daily Star Bangladesh (2015). Dhaka slum dwellers among most vulnerable to climate change. [online] The Daily Star. Available from: https://www.thedailystar.net/city/dhaka-slum-dwellers-among-most-vulnerable-climate-change-83347 (Accessed 8 August 2018).

Thompson, J., Porras, I., Tumwine, J., Mujwahuzi, M., Katui-Katua, M., Johnstone, N., &Wood, L. (2001). Drawers of Water II: 30 Years of Change in Domestic Water Use and Environmental Health in East Africa; International Institute for Environment and Development: London, UK. p 107.

UKCIP (2004). Costing the impacts of climate change in the UK, Oxford UK. Available from: http://www.sfrpc.com /Climate%20Change/7.pdf (Accessed 26 June 2017).

UK Met Office Hardley Centre (2011). Climate: Observations, projections and impacts. Available at:http://eprints .nottingham.ac.uk/2040/16/Kenya.pdf (Accessed 26 July 2018).

UNDP (2004). Reducing Disaster Risk, A Challenge for Development. Available from: http://www.undp.org/content/undp/en/home/librarypage/crisis-prevention-and-recovery/reducing-disaster-risk--a-challenge-for-development.html (Accessed 8 September 2016).

UNISDR, UNDP. (2012). Disaster Risk Reduction and Climate Change Adaptation in the Pacific: AnInstitutionaland Policy Analysis. Available at: http://www.unisdr.org/files/26725_26725drrandccainthepacificaninstitu.pdf (Accessed14 November 2017).

UNDP, &UNISDR (2007). Handbook on good building design and construction: Aceh and Nias islands. Available from http://www.unisdr.org/we/inform/ publications/1525. (Accessed 26 June 2017).

UNECA (2013). Climate Change and Water in Africa: Challenges, Opportunities and Recommendations. Availablefrom:https://www.uneca.org/sites/default/files/PublicationFiles/policy_brief_4 _climate_change_and_water_in_africa_challenges_opportunities_and_recommendations.pdf (Accessed 5 Sep. 2017).

UNFCCC (2009). Adaptation to Climate Change: Linking Disaster Risk Reduction and Insurance. Available from: https://unfccc.int/resource/docs/2009/smsn/ngo/163.pdf (Accessed 9 March 2017).

UNFCCC (2011). Climate Change and Freshwater Resources. Available from: http://unfccc.int/resource/docs/publications/11_nwp_clim_freshwater_en.pdf(Accessed10 November 2016).

Urban Transects Kisumu (2016). Urban Zones in the Study of Kisumu. Available from: http://dyceacademy.aberdeen.sch.uk/wp/wp-content/uploads/2010/08/Urban-Transects-Kisumu.pdf (Accessed 5 September 2016).

UN-HABITAT (2003). The Challenge of Slums, The State of the World Cities Report 2012/13. Available from: https://unhabitat.org/wp-content/uploads/2003/07/GRHS_2003 _Chapter_01_Revised_2010.pdf (Accessed on 3 November 2016)

UN-HABITAT. (2004). Kisumu City Development Strategies. Available from: http://mirror.unhabitat .org/downloads /docs/3589_41974_kisumu_cds.pdf (Accessed 4 November 2016).

UN-HABITAT (2007). Understanding the Grassroots Dynamics of Slums in Nairobi: The Dilemma of KiberaInformal Settlements. Available from: https://www.scribd.com/document/53314814/ Understanding-the-Grassroots-Dynamics-of-Slums-in-Nairobi-The-Dilemma-of-Kibera-Informal-Settlements (Accessed 6 August 2016).

UN-HABITAT. (2008). Harmonious Cities: State of the World's Cities 2008/9. Available from: https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=1119&menu=35 (Accessed 4 November 2016).

UN-HABITAT.(2009). Global Report on Human Settlements, 2009: Planning Sustainable Cities United Nations Human Settlements Programme. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1002/psp.616 (Accessed 22 June 2016).

UN-HABITAT. (2014). The State of African Cities 2014: Re-Imagining Sustainable Urban Trajectories; United Nations Human Settlements Programme. Available from: https://www.gwp.org/globalassets/global/toolbox/references/the-state-of-african-cities-2014_re-imagining-sustainable-urban-transitions-un-habitat-2014.pdf (Accessed 30 June 2017)

UN-HABITAT.(2015). Situation Analysis of Informal Settlements in Kisumu; United Nations Human SettlementsProgramme,Availablefrom:https://books.google.co.ke/books/about /Situation_Analysis_of_informal_settlemen.html?id=RGUMSW36Wp0C&redir_esc=y (Accessed 5 Sep 2017).

UNICEF (2016). Water, Sanitation and Hygiene. Climate Change. Available at: https://www.unicef.org/wash /3942_4472.html (Accessed 5 Sep. 2017).

UNISDR Asia, & Pacific. (2009). 12062_TownWatching Handbook for Disaster Education., Available From http://www.unisdr.org/files/12062_TownWatching .pdf(Accessed 22 June 2017).

UNISDR (2015). Sendai Framework for Disaster Risk Reduction2015 - 2030. [online]. Available from:http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf (Accessed 30 June 2017).

UNISDR. (2012). United Nations international strategy for disaster reduction: Hyogo Framework for Action. Available from: https://www.unisdr.org/we/inform/publications/25129 (Accessed 17 October 2016)

Wamsler, C. and Brink, E. (2013). *Moving beyond short-term coping and adaptation*. Available from:

http://portal.research.lu.se/ws/files/1650180/4392225.pdf (Accessed 6 December 2016).

Wandiga, S. (2006). Climate Change Induced Vulnerability to Malaria and Cholera in the Lake Victoria Region. Available from:http://www.start.org/Projects/AIACC_Project/Final%20Reports /Final%20Reports/FinalRept_AIACC_AF91.pdf (Accessed15 November 2016).

Wandiga, S., Opondo, M., Olago, D., Githeko, A., Githui, F., Marshall, M., Downs, T., Opere, A., Oludhe, C. , Ouma, G., Yanda, P., Kangalawe, R., Kabumbuli, R., Kathuri, J., Apindi, E., Olaka, L., Ogallo, L., Mugambi, P., Sigalla, R., Nanyunja, R., Baguma, T. and Achola, P. (2010). Vulnerability to epidemic malaria in the highlands of Lake Victoria basin: the role of climate change/variability, hydrology and socio-economic factors. *Climatic Change*, 99(3-4), pp.473-497.

Wong, A. (2018). Cities around the world should prepare for running out of water, experts say. Available at: https://www.cnbc.com/2018/04/11/cape-town-water-crisis-cities-should-prepare-for-water-scarcity.html (Accessed 19 July 2018).

WaterAid. (2013). Hand-Dug Wells—Technical Brief; WaterAid: London, UK, Available from:http://water aid.org/technologies (Accessed on 17 October 2016).

World Bank. (2008), Approaches to urban slums. Available from: https://openknowledge.worldbank.org/ha ndle /10986/6304 (Accessed 22 June 2017).

World Bank. (2010): Cities and Climate Change: an urgent agenda, The International Bank for Reconstruction and Development and The World Bank, Available from: http://web.worldbank.org/wbsite/external/topics/exturbandevelopment/extuwm/0,contentMDK:22781089~pagePK:210058~piPK:210062~theSitePK:341511,00.html (Accessed 8 September 2016).

World Bank. (2011). Climate Change, Disaster Risk, and the Urban Poor Cities Building Resilience for a ChangingWorld.Availablefrom:http://siteresources.worldbank.org/INTURBANDEVELOPMENT /Resources/336387-1306291319853/Summary.pdf (Accessed 7 September 2016).

World Bank. (2011). Essential Three: Multi-hazard Risk Assessment-Know your Risk. Available from:http://www.unisdr.org/campaign/resilientcities /toolkit/essentials/view/3. (Accessed 22 June 2017).

World Bank. (2013). Climate Change Impacts on Water Resources and Adaptation in the Rural Water Supply and Sanitation Sector in Nicaragua. Latin America and Caribbean Region Environment and Water Resources. Available from: https://openknowledge.worldbank.org/handle/10986/16586 License: CC BY 3.0 IGO." (Accessed 2 November 2016).

World Bank. (2016). Poverty Analysis - Measuring Vulnerability. Available from: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20238993~menuPK:492141~pagePK:148956~piPK:216618~theSitePK:430367,00.html (Accessed 1 November 2016).

WHO (2009). WHO | Slums, climate change and human health in sub-Saharan Africa. Available from: http://www.wh o.int/bulletin/volumes/87/12/09-073445/en/ (Accessed 5 Sep. 2017).

WHO-UNICEF (2013). Report of the second consultation on post-2015 monitoring of drinking-water, Sanitation and hygiene, The Hague. Available from: https://www.unicef.org/wash/files/2_WSSCC_JMP_Fact_Sheets_2_UK_LoRes.pdf (Accessed 6 September 2017).

WHO (1997). World Health Organization. Guidelines for Drinking Water Quality, Second edition,

Vol.3. Available from: http://www.who.int/water_sanitation_health/dwq/gdwqvol32ed.pdf (Accessed 7 September 2017).

Yasmin, S. (2016). Climate Change Effect in Physical and Natural Capital: A Study on Urban Poor in Dhaka Cityof Bangladesh. Available from: https://www.omicsonline.org/open-access/climate-change-effect-in-physical-and-natural-capital-a-study-on-urban-poor-in-dhaka-city-of-bangladesh-2167-0587-1000170.pdf (Accessed 8 August. 2018

APPENDICES

Appendix A: Field Questionnaire

Household Questionnaire

Name of informal settlement: _____

Location/Village: _____

Name of interviewee: _____

GPS Location: _____

General Information

1. Age:
   - Less than 20 [ ] 20- 29 [ ] 30-39 [ ] 40- 49 [ ] 50 + [ ]

2. Gender:
   - Male [ ] Female [ ]

3. Marital status:
   - single [ ] married [ ] separated [ ] widowed [ ]

4. Level of education:
   - Primary [ ] Secondary [ ] College [ ] University [ ] No education [ ]

6. Main occupation
   - Employed [ ] Own business [ ] Unemployed [ ] Jua kali [ ] Farming [ ]

7. How long have you stayed in this area (years)?
   - Less than a year [ ] 1-5 [ ] 6-10 [ ] 11-15 [ ] 16 + [ ]

8. How many people live in your Household?
   - 1-5 [ ] 6-10 [ ] 11-15 [ ] 16 + [ ]

Water Source

9. What is the main source of drinking water for your household?
   - Piped water [ ] Well water [ ] Water vendors [ ] Surface water [ ] River [ ] Borehole [ ]

b) Is the main source of water reliable? [NB: Take notes on why it is not reliable]
   - Yes [ ] No [ ]

7. How frequent do you use the water from other sources for drinking?
   - Always [ ] Sometimes [ ] Rarely [ ] Other ……

8. What are the alternative sources of water that you have? [NB: They can check more than one]
   - Rain water harvesting [ ] Roof catchment [ ] Shallow wells [ ] Deep wells [ ] Rivers [ ] Ponds [ ]

Water Use

9. What is the main water use:
   - Drinking [ ] Cooking [ ] Personal Hygiene [ ] Flushing toilet [ ] Other …….. [ ]

b) What is the source for each of the water uses you have mentioned above?

……

10. What are the other uses of water?
    - Agriculture [ ] Construction [ ] Livelihoods [ ] Carwash [ ] Other…….. [ ]

b) What is the source for each of the water uses you have mentioned above?

……

11. How frequent do you use the water from the potable water source for drinking?
    - Always [ ] Sometimes [ ] Rarely [ ] Other …… [ ]

12. What is the impact of flood on water use? [Prompt also "why"? and take notes]
    - Lack of water for drinking [ ] Lack of water for personal hygiene [ ]

Lack of water for farming/ livestock [ ] Other…… [ ]

13. What is the impact of drought on water use? [Prompt also "why"? and take notes]

    - Lack of water for drinking [ ] Lack of water for personal hygiene [ ] Lack of water for farming/ livestock [ ]

Other…… [ ]

Water Supply

14. What is the distance you walk to fetch water?
    - Less than 10m [ ] 10-50m [ ] 60-100m [ ] 100-150m [ ] more than 1km[ ]

15. How many days per week is the water supply available from your main source?
    - 1-2 [ ] 2-3[ ] 3-4 [ ] 4-5 [ ] 5-7 [ ] 7- 14 [ ] Other…….. [ ]

16. Do you have connectivity to water supply system from KIWASCO?
    - Fully connected [ ] Partially connected [ ] Not connected [ ]

17. Is the water sufficient for domestic consumption?

- Yes [ ] No [ ]

18. What are the possible causes of reduced water supply?

- Electricity supply [ ] Low water pressure from the sources? [ ]
- Source contamination [ ] Poor wastage management [ ]
- Reduced water levels at sources due to overexploitation [ ]
- Other …….. [ ]

19. What is the impact of Drought on water supply? [Prompt also "why"? and take notes]

- Water shortage [ ] Water resource conflict [ ]
- Increased demand of water [ ] Lack of drinking water for livestock animals [ ]
- Lower levels in reservoirs, lake and ponds [ ] Other …… [ ]

20. What is the impact of Flooding on water supply? [Prompt also "why"? and take notes]

- Water shortage [ ] Water resource conflict [ ]
- Increased demand of water [ ] Lack of drinking water for livestock animals [ ]
- Lower levels in reservoirs, lake and ponds [ ] Other …… [ ]

Water Quality

21. How does your water appear?

- Clear [ ] turbid [ ] with visible suspended matter [ ]
  Other…….[ ]

22. How does your water taste?

- Good soft [ ] Bad salty [ ] Bitter [ ] Bad muddy taste [ ]

23. Does your water smell?

- Yes [ ] No [ ]

24. How do you treat your water?

- Add bleach/chlorine [ ] Boil [ ]
  Strain through a cloth [ ] Water guard [ ]
  other…… [ ]

25. Has your family suffered from the following?

- Diarrhoea [ ] Typhoid [ ] Worms [ ] Cholera [ ] Bilharzias [ ]
  Hepatitis [ ] Other [ ]

26. What is the impact of Drought on water quality?

- Water contamination [ ] Pollution of water sources [ ] Sanitation challenges [ ] Low fish production [ ] Disease outbreak [ ]
  Other…… [ ]

27. What is the impact of Flood on water quality?
    - Water contamination [ ] Pollution of water sources [ ] Sanitation challenges [ ] Low fish production [ ] Disease outbreak [ ]
      Other…… [ ]

Social Impact

28. To what extent do climate extremes affect your health?
    - Drought: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]
    - Flood: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]

29. To what extent do climate extremes cause loss of life?
    - Drought: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]
    - Flood: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]

30. Does an increase in temperature cause water pollution problems in natural sources e.g. algal blooms?
    - Not so much [ ] very much [ ] Not affected [ ]

31. Do climate extremes affect your livelihoods? [Prompt for HH main livelihood]
    - Drought: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]
    - Flood: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]

32. To what extent do extreme events damage critical infrastructure for water supply?
    - Drought: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]
    - Flood: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]

Vulnerability

33. How frequent do you experience devastating floods in your area?
    - Always [ ] Seasonally [ ] Regularly [ ] Never [ ]

34. How frequent do you experience devastating drought in your area?
    - Always [ ] Seasonally [ ] Regularly [ ] Never [ ]

35. Do climate extremes affect you daily Income?
    - Drought: Always [ ] Regularly [ ] Sometimes [ ] Never [ ]
    - Flood: Always [ ] Regularly [ ] Sometimes [ ] Never [ ]

36. How are community water sources affected by?

- Drought: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]
- Flood: Not so much [ ] very much [ ] Not affected [ ] N/A [ ]

Access to basic facilities

37. Does flooding affect general movement around the estate?
    - Very much [ ] not so much [ ] Not affected [ ]

38. Does flooding affect children going to school?

    - Very much [ ] not so much [ ] Not affected [ ]

39. Does flooding affect access to important facilities within the estate (e.g. hospitals, churches, mosques etc.)?

    - Very much [ ] not so much [ ] Not affected [ ]

40. Does flooding affect existing infrastructure within the estate (road network and small pathways)?

    - Very much [ ] not so much [ ] Not affected [ ]

Socio- Economic Vulnerabilities

Solid waste Management

41. What is the main source of human waste disposal in your household?
    - Flush [ ] Pit Latrine [ ] Bucket toilet [ ] Composting toilet [ ] No facility [ ] Other [ ]

42. What is the distance between your water source and toilet facility?

    - Less than 5m [ ] 10-20m [ ] 30- 50m [ ] 60-70m [ ] more than 100m [ ]

43. How frequent is the garbage collected?
    - Daily [ ] Weekly [ ] Monthly [ ] Not Collected [ ]

44. What is the major problem with solid waste management in the community?

    - Lack of waste containers [ ] Lack of enforcement [ ]
    - Lack of regular collection [ ] Increasing population [ ]
    - Lack of knowledge and training [ ] Lack of sufficient capital [ ] Other [ ]

45. How do you dispose of your refuse?

    - Waste bins [ ] Dumping in nearby bushes [ ]
    - Dumping in River/Lake Burning [ ]
    - The use of municipality facilities and services [ ] Other……. [ ]

46. Do you have a drainage system in this area?
    - Yes [ ] No [ ]

47. Do you have flood water outlets in this area?
    - Yes [ ] No [ ]

Income

48. How much do you earn per month?
    - Less than 1000 Ksh [ ]
    - 1000-5000 Ksh[ ]
    - 5000 10000 Ksh[ ]
    - More than 10000 Ksh[ ]
    - Not applicable[ ]

Energy

49. What fuel do you use for Cooking and Lighting?
    a) Cooking – Firewood [ ] Charcoal [ ] Kerosene [ ] Gas [ ] Other …… [ ]

    b) Lighting – Electricity [ ] Kerosene lamp [ ] Solar lamp [ ] Candle [ ] Other ……[ ]

Housing

50. What material do you use to build your house?

    - Corrugated iron sheets [ ] Mud and Pole [ ] Brick walls [ ] Other…….. [ ]

51. Do you have legal ownership or title deeds for your house?
    - Yes [ ] No [ ]

Health

52. What types of health service exists in your area

    - Hospitals [ ] Clinics [ ] Dispensary [ ]
    - Mobile clinic [ ] None [ ]

53. What are the most common environment and health problems that you face in the city in relation to Dry spells?

    - Typhoid [ ] Cholera [ ] Amoeba [ ] Dysentery [ ] Diarrhea [ ] Other…… [ ]

54. Which of the following diseases were experienced by the household members following Flooding?

    - Malaria/ Fever [ ] Flu [ ] Pneumonia [ ] Schistosomiasis [ ] Measles [ ] Other…… [ ]

Biophysical Vulnerabilities

55. When is the highest water level in the rivers noted?

- October – November- December[ ] January – February- March[ ]
- April – May- June [ ] July – August - September [ ]

56. When do you experience drought season?

- October – November- December[ ] January – February- March[ ]
- April – May- June [ ] July – August - September [ ]

57. What is the lowest level you have ever seen the river?

- Sometimes the river dries up [ ] Less than 1m (One can walk across it) [ ]
- 2 – 4 m above the river bed [ ] more than 4m above the river bed [ ]

58. What is the highest water level you have ever seen in your houses during periods of heavy rains in house?

- Less than 0.5m [ ] 0.5 to 1.0m [ ] 1.0-1.5m [ ] 1.5-2.0m [ ] More than 2m [ ]

9 When do you experience high floods

- At the beginning of rainy season [ ] Mid rainy season [ ]
- Towards the end of rainy season [ ] I don't know [ ]

59. Has the river changed its course since you started living in this area?

- Yes it has [ ] Maybe it has [ ]
- No it has not [ ] I do not know [ ]

60. Have you noticed any changes in the rate at which mud drains after heavy rain?

- Yes, the mud takes a longer time to drain compared to some years ago. [ ]
- Yes, the mud takes a little longer to drain compared to some years ago [ ]
- Yes, the mud takes a little time to drain compared to some years ago. [ ]
- No, I have not noticed any changes [ ]

61. How long does it take you to get to the closest access to clean water?

- 5 – 10 min walk [ ] 10 – 30 min walk [ ] 30 – 1hr walk [ ] More than 1 hour walk [ ]

62. Is there anything that you believe is making the impact of flooding worse?

- poor wastage management [ ]
- overcrowding of houses[ ]
- lack of outlets for flood water[ ]
- Other …….. [ ]

Climate information

63. What is your opinion of climate change in this area?

- Floods [ ] Drought [ ] Both drought & floods at different times [ ]
  Other…… [ ]

64. How do you access climate change information?

- Radio [ ] Chiefs Baraza [ ] in church [ ] TV [ ]
  other…….. [ ]

Adaptation

65. What is the community doing to cope with clean water shortage?
    - Water Storage in Containers [ ] Extend water pipe lines to their home [ ]
      Establishing Communal Water Points [ ] Digging Boreholes/ Shallow Wells [ ]
      Purchasing wheel barrows to carry large amount of water [ ]
      Other…….. [ ]

66. What measures have you put in place to manage Flooding?
    - Dig big trenches [ ] Relocate [ ]
    - Use sand bags to prevent floods [ ]
      Other……. [ ]

67. Are they signs you see before Drought occurs?
    - Yes [ ] No [ ]

    b) If Yes which signs do you see

……
……

68. Are there signs you see before Flooding occurs?
    - Yes [ ] No [ ]

    c) If Yes which signs do you see

……
……

69. Which strategies have been put into place by government to manage flood & drought and the availability of water in the future? [can check more than one]

    - Maintenance of water pipes for water supply [ ]
    - Early warning before flooding / drought happens [ ]
    - Education and training on drought & flooding [ ]
    - Upgrading critical infrastructure for water supply and sanitation [ ]
    - Managing water demand [ ]
    - Improve in water and sanitation planning [ ]
    - None [ ]

70. Which strategies have been put into place by NGOs to manage flood & drought and the availability of water in the future? [can check more than one]

    - Maintenance of water pipes for water supply [ ]
    - Early warning before flooding / drought happens [ ]
    - Education and training on drought & flooding [ ]
    - Upgrading critical infrastructure for water supply and sanitation [ ]

- Managing water demand [ ]
- Improve in water and sanitation planning [ ] None [ ]

71. Do you think the County Government has given support on Flooding and Drought issues?
    - Yes [ ] No [ ]

72. Do you think the National Government has given support on Flooding and Drought issues?
    - Yes [ ] No [ ]

APPENDIX B: KEY INFORMANT INTERVIEWS

Key Informant interview 1

Name……Charles Okaka…- Urban Water services provision- Officer…….

Date……2/6/17……

Organization…Ministry of Water Kisumu county…….

1. What is your perception of climate change in urban informal settlements?

- The river levels, boreholes, and streams are affected with receding water levels when water is drawn
- Production is affected for farmers in the area
- The quality water is affected in flooding period and during drought
- climate change renders supply and quality of water

2. How do people in these settlements access climate change information?

- The communities are not informed

3. What is the main source of water in the area?

- Lake Victoria, Kajulu river, Kibos and several boreholes, and shallow wells (most contaminated and 10m deep) they are contaminated because of ground silage.

4. What are the main uses of water?

- Domestic use
- Health centres
- food business and other commercial business

5. What is the major cause's water supply shortage in the settlements?

- Dry periods cause water shortage, a jerrycan which costs 5 shillings in terms of price can rise to 20 shillings.
- Abstraction of water Is difficult in dry period
- Pipe bursts are also a major cause of water shortage especially along major roads e.g. Kakamega- Kisumu pipeline and it taken time to be repair the water pipes

- The water infrastructure is old and needs to be replaced and causes several bursts
- There is shortage of water tanks

6. What are the general water-related problems in this area in Wet/Dry periods?

- Flooding affects pollution because pit latrines overflow causing water contamination in water source
- Water bone diseases are common e.g.cholera , dysentery, amoeba,
- Flooding damages the water infrastructure
- Water hyacinth Block absorptive pipelines
- Because of flooding the water intakes becomes silted because the silt load from the agriculture
- Water catchment areas. are affected because they are polluted
- High turbidity and water needs a lot of chemicals to treat water

Dry periods-

- water scarcity
- Contamination of sources and disease out break

7. How should the community deal with the water shortage challenges?

- Ownership and operation of existing systems
- Participation on the management of water systems which are coming up and taking care of the resources.
- They should embrace good governance
- They should be prudent use of available resource
- They should participate in develop water project like new boreholes which are being built by the government
- They should stop vandalism of water networks which requires capacity building
- They should register in groups for social services and open bank accounts where they deposit money if they are left with the water projects to run.

- The communities have to be trained on management of the water system and accounts
- Protect the environment and water catchment areas and not cut trees anyhow
- The community should donate land to build the water system
- High population which cannot meet the demand of water
- The community should be sensitized on the benefits of water systems and have an ownership to the systems to prevent vandalism even activity has to be budgeted for because repair is not easy.
- Compensation for the land owners were systems have been put in place.
- Water conflict resolution for some systems which are non-operational Nandi and Kisumu county (ownership).

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- The land ownership of land to build dams has been a problem.
- The county government has been assisting in construction of hand dug wells about 50 meters deep for water storage.
- Underground tanks have been built in the urban areas.
- There has been a policy which has been passed on the people who build houses should have a storage tank and a Rain water harvesting storage (Water Policy 2016).

9.Who is responsible for water management of the municipal council water sources?

- KIWASCO, NYANAS, GULF they have been rendered un operational because of poor management so KIWSCO has taken over.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- There is a policy but it does not have those components

11. What is your recommendation on sustainable water supply in your village?

- The cost of electricity is high and delayed payments causes disruption of water supply. The use of solar water management systems will ensure sustainability of water

supply in the future.

- Rehabilitate old worn infrastructure and pumping plants.
- Prudent management of water systems and financial resources.
- Stopping corruption especially in reading of meters.
- They should aim at reducing the No revenue water levels (which are not accounted for).
- There are un-metered connections should be minimized and these meters read biased consumption.
- Meter Reading errors should be minimized because of some are outdated and need to be replaced.
- Road construction programme and the optic fiber networks should be monitored because they disrupt main lines.
- Enhance revenue collection on water used in instalments and reactivate dormant accounts and allow owners to pay in instalments.
- All water connections should be metered in some areas they use estimation and pay for the exact amount of usage.
- Prudent use of good governance every water used should be accounted for
- Technical staff managing the systems should be qualified – some of the staff just distribute without putting treatment.
- Water quality tests should be done regularly, lab equipment and apparatus and re-agents for PH should be done regularly.
- The compound where the water works should be properly fenced and guarded by security to keep of animals and intruders which interfere with the water system.
- Repair fitting equipment is required and should be done immediately.
- In informal settlements, they should introduce bulk meters to measure the quantity of water which is being sold.

Key informant interview 2

Name……Mr Harun Gullah… Date……5/6/17……

Organization…Ministry of environment - Kisumu…….

1. What is your perception of climate change in urban informal settlements?

- The impact of climate change in the slums is water and sewerage system. The KIWASCO was given a mandate to provide sewerage systems in the Kisumu city and provide waste water in treatment in technologies and compliance. The issue of water and sanitation in the slums is the poverty level the housing and planning and adherence to environment sounding principles (EMCA 1999) to ensure everyone has a clean environment. According to the EMCA they do not sink borehole with 30 m within the proximity of a pit latrine. The water table is high and contamination is very high.

- The challenge in the slums is the physical infrastructure the channelling water and waste and discharge in the environment.

- There is water contamination because of leeches and seasonal rivers and wetlands adjacent to the pile of dumpsite and the usage of that water is in urban informal settlements and diarrhoea and typhoid is high.

- In Nyalenda decomposing of the dumping site materials the GHG that emits from that dumpsite affect aspects of air pollution, the leeches contaminate water and cancer has been prominent.

2. How do people in these settlements access climate change information?

- There is a communication strategy and in addition I have a talk show every Thursday -call in programme. I launched a mentorship strategy on communication we start environment education clubs and group on awareness centres waste management, water sanitation, tree planting.

- They also receive information through Barraza's - though the level of education level is low

- Interest of the inhabitants on climate change is not high so they might not be interested to hear about it.

3. What is the main source of water in the area?

-KIWASCO did a road entry and opened water point but the population against the demand of water is too high

- Rain water harvesting and tapping from main stream (river)

4. What are the main uses of water?

- Domestic use

- Urban agriculture (Programme) Kisumu integrated solid waste management and the issues are recycling and kitchen gardening, Land tenure is an issue in the area it is minimal.

5.What is the major cause's water supply shortage in the settlements?

- KIWASCO is a profit-making company and they need revenue treatment and infrastructure and they expect inhabitants to pay for water use which they cannot afford. KIWASCO does not want to supply water for free.

- The shallow wells are adjacent to the water source.

- Water hyacinth is a big problem it reduces water quality.

- Development is ahead of planning the planning for Kisumu city is for the 1960s. Slums have no proper planning. The low-income people during colonial time were living un-designated areas in the slums especially house help.

6. What are the general water-related problems in this area in Wet/Dry periods?

- In dry periods KIWASCO does not supply water tanks.
- The flooding aspect is more than we expected in previous years' water infiltration, sinking and absorption is less because of the water table is very high.
- People are being displaced in low lying areas.
- Deforestation in the Mau has caused increased water levels down slope.

- There is a problem of evacuation when heavy rains pour the residents do not want to move because they are ancestral lands.

7. How should the community deal with the water shortage challenges?

- To come up with a structure of organization KIWASCO should have a community for water points up to their home stead.

- Developing rain water harvesting system.

- Establishing water vendor organization for clean water supply.

- Water tank vending.

8.Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

-EMCA1999 right is part of the strategy. KIWASCO policy is to provide safe water to the community. There are community based set ups in the peri-urban in KIWASCO

9. Who is responsible for water management of the municipal council water sources?

-KIWASCO it is their business to supply water and is accountable to failure, the is private and owned by the county government

10. Are there any water supply and sanitation policies in place that deal with climate change?

- There are policies which are ISO certified

- vision 2030 even international treaties

- in the SDGs, there is a guideline in place

- when hyacinth had a problem and there was an outcry

11. What is your recommendation on sustainable water supply in your village?

- Strengthen institution policy within the institution and compliance

72.1 Key informant interview 3

Name……Fred Nyongesa…….. Date……28/11/16……

Organization……WRA…….

1.What is your perception of climate change in urban informal settlements?

- Climate change is more pronounced in rural settings unlike in urban areas. Rural settings rely on natural resources and their options are limited.

2. How do people in these settlements access climate change information?

- WRMA established, Water Resource Users Association (WRUA) which is a platform for communities and organisations to come together and discuss with them about climate change issues and this enables all urban settings to understand climate change in all the areas they have mapped out to be hotspots.

5. What is the main source of water in the area
- Rivers
- Lake Victoria

6. What are the main uses of water?
- Horticulture on small scale
- Drinking
- Fish ponds

5.What is the major cause's water supply shortage in the settlements?

- Unplanned development, the expansion of sewer systems does not match the development taking place.
- Vandalism of infrastructure by the slum dwellers.
- It is difficult to supply water and collect waste in the urban informal settlements

because of the closeness of the houses and the building planning

6. What are the general water-related problems in this area in Wet/Dry periods?

Wet period:

- Non-point sources of pollution endangered
- Disruption of water supply infrastructure
- Flooding makes breeding grounds for mosquitoes

Dry Periods:

- Water conflict
- Water sources pollution

7. How should the community deal with the water shortage challenges?

- Water harvesting
- Sub- catchment management plans
- Water rationing

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- WRMA has installed early warning systems which are integrated with indigenous knowledge. The early warning systems areconcrete pillars on sites of the river bank and it is marked and when the communities see it red it means danger and they should warn people to move to safer grounds.

9. Who is responsible for water management of the municipal council water sources?

- WRMA is in charge of both services and groundwater and it issues our permits to clients to use water resources.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- Water Services Regulatory Board (WASREB) is responsible for water and sanitation

policies to deal with climate change

11. What is your recommendation on sustainable water supply in your village?

- Integrated approach to engage communities
- Proper management of catchments to enhance water quality and quantity
- Observe water management and regulatory policies
- Legal usage of water and environmental standards not to endanger people's lives so as to have sustainable water
- Water is important to socio- economic development, enhancing water quality and quantity to legal requirements of Water Act 2002. Water Act 2016 does not pronounce climate change issues

Key informant interview 4

Name……Caroline Odera……. Date……5/12/16……

Organization……KIWASCO……

1.What is your perception of climate change in urban informal settlements?

- The perception of climate change in the informal settlements is flooding and when it rains the KIWASCO company has no business because the slum dwellers harvest rain water and during drought periods KIWASCO has business though there is a lot of competition with shallow wells.

2. How do people in these settlements access climate change information?

- Most of the people get this information through Radio and TV

3. What is the main source of water in the area

- The main source of water in the informal settlements is from KIWASCO.KIWASCO has established water kiosks for those residents who cannot connect directly. The residents also use wells and the river water alongside with the KIWASCO water.

4. What are the main uses of water?

- The piped water is for drinking and cooking and a small percentage of the population use KIWASCO water for personal hygiene.

5.What is the major cause's water supply shortage in the settlements?

- Lack of finances for the slum dwellers to connect to KIWASCO water. The residents feel KIWASCO water is expensive although it is subsidised.

6. What are the general water-related problems in this area in Wet/Dry periods?

- Infectious diseases are prominent especially cholera though it has reduced.

7. How should the community deal with the water shortage challenges?

- KIWASCO has sensitised the residents on why it is important to use clean water unlike the alternative sources of water they use.

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- KIWASCO has storage tanks where they store water especially for their clients.

9. Who is responsible for water management of the municipal council water sources?

- Lake Victoria south water services.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- KIWASCO is coming up with a socio- economic policy in the informal settlements so that the company gives loans for the slum dwellers to connect.

11. What is your recommendation on sustainable water supply in your village?

- The communities relied on NGOs to help them and they should contribute to development to water and sanitation because it is for their own good. NGOs are now pulling out from funding the residents to connect water pipes from KIWASCO. The residents need to be trained on the importance of clean water.

- KIWASCO has introduced Community Based Organisations to manage water and sell water and they sell at a subsidised price

Key informant interview 5

Name……Rafael Kapiyo…… Date……24/11/16……

Organization……SANA International …….

1.What is your perception of climate change in urban informal settlements?

- The informal settlements have issues with the availability of water and the government is trying to make the water available in these areas, not all of the areas have sewer systems and the major problem is flooding.

2. How do people in these settlements access climate change information?

- The slum residents do not access the information directly, though they are taught by SANA about cleanliness in their homes.
- Climate change disaster happen when they are unaware because they do not have the knowledge on climate change.

3. What is the main source of water in the area

- KIWASCO is the main provider of water in this area though SANA also provides water services in this area. SANA has also extended boreholes in addition to KIWASCO water.

4. What are the main uses of water?

- Drinking
- Household use
- Farming
- Construction

5.What is the major cause's water supply shortage in the settlements?

- The assumption is that water is available in the informal settlements because of water kiosk but the residents cannot afford this water.

- KIWASCO does not have enough water to supply the slum residents the water is not enough for household use

6. What are the general water-related problems in this area in Wet/Dry periods?

- There are long ques and the residents are forced to walk long distances in search of water. Water conflicts arise and there is tension between the residents and the government.

7. How should the community deal with the water shortage challenges?

- The residents who depend on water kiosks have issues with the kiosk owners. Though they depend on shallow wells.

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- There is no proper strategy put in place to manage climate extremes. The communities are victims of circumstance and they should work together to access water and avoid using stream water.

9. Who is responsible for water management of the municipal council water sources?

- KIWASCO is the main provider of water then development organisations like SANA which prioritises schools.
- Individual well owners are also another source of water.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- Water Act 2015 which has been revised. This Act has the provision for community and the government partnershipsand water user's associations which offer safe use and availability of water.

11. What is your recommendation on sustainable water supply in your village?

- Priorities should be there to make water available. Climate Change should be dealt with by reducing emissions because the informal settlement residents are vulnerable and the state has not given provision on availability of water.
- Communities need organisations which are local training them on climate change because it is affecting everyone and they should be trained on how to detect and respond to climate change.
- The communities should be also involved in activities carrying messages of climate change and the impacts of climate change.
- There is also need for information centres which provide information on emerging issues and transfer relevant information.

Key informant interview 6

Name……Jane Akendo……. Date……24/11/16……

Organization……Wandiege Water and Sanitation company…….

1.What is your perception of climate change in urban informal settlements?

- The informal settlements experience flooding during rainy season and they are no flood outlets for water.

- During drought period the individual households who own cattle are affected because of reduced grazing areas for the cattle.

2. How do people in these settlements access climate change information?

- Some of the residents access this information through radio and TV. The other residents do not have time to listen to the radio because of work and also, they might be too tired to listen the radio after work.

3. What is the main source of water in the area

- The main source of water in the area is borehole water from Wandiege company which costs 20 shillings per jerry can and KIWASCO company from the lake.
- Other residents harvest rain water and use roof catchment.

4. What are the main uses of water?

- Livestock
- Farming

- Domestic purposes
- Car Wash

5.What is the major cause's water supply shortage in the settlements?

- Finances to extend water pipes to other communities.
- Electricity outage is the main problem for water shortage, Kenya power has tried to introduce a pre-paid system. High costs of power have also contributed to reduced water supply.
- Breakage of water pipes which contaminates water and affects water quality.
- Soak pits are also another major hazard because you cannot extend pipes.
- Water salinity

6. What are the general water-related problems in this area in Wet/Dry periods?

- Problems related to water have reduced because Wandiege is a nearer source of water and they can afford. Wandiege also supplies free water to the elderly in the community to avoid them using contaminated water.
- No outbreaks have been reported in the area because the facility tests water quality after every three months for precaution.

7. How should the community deal with the water shortage challenges?

- The communities should be sensitized to pay bills on time to avoid disconnection.
- The communities expect the water is free they need to be sensitized on that too and the importance of clean water.

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- Wandiege is hoping to build a larger reservoir to store water especially during the cloudy season when we cannot use solar system. If we cannot access solar we cannot use Kenya power electricity it is not reliable.

9. Who is responsible for water management of the municipal council water sources?

- Lake Victoria Services Board is responsible for water management. They licence and manage all the water in the region and regulate water supply companies like us.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- Bill of 2014 was stating that small operators should go under private management but we have not heard anything after the bill was passed.

11. What is your recommendation on sustainable water supply in your village?

- The water supply will be sustainable in the villages if we receive water from KIWASCO in bulk and if we have more income by addressing challenges in the facility.
- Wandiege needs to give people meters so that volume is not lost to be able to know what people have consumed and how much the company is producing.

Key informant interview 7

Name……Purity Gati…….……... Date……28/11/16……

Organization…Lake Victoria South Water Services Board……...

1.What is your perception of climate change in urban informal settlements?

- There is no adaptive capacity in the informal settlements because there is no development taking place.

2. How do people in these settlements access climate change information?

- The government sensitises the communities and even the Meteorology department sends messages but they need to be simplified because the communities do not understand what is climate change.

3. What is the main source of water in the area

- The main source of water is KIWASCO followed by shallow wells, rivers and rain water harvesting.

4. What are the main uses of water?

- Domestic use
- Construction
- Agriculture

5.What is the major cause's water supply shortage in the settlements?

- Main streams are not regulated
- Polluted water sources

6. What are the general water-related problems in this area in Wet/Dry periods?

- Low production of agriculture and disease outbreak

7. How should the community deal with the water shortage challenges?

- The community should be sensitised about water harvesting

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- They are integrated approaches to work with communities which have been put in place with Lake Victoria South Water Services Board

9. Who is responsible for water management of the municipal council water sources?

- We are responsible for water management including WRMA and KIWASCO.

10. Are there any water supply and sanitation policies in place that deal with climate change?

- Climate change Act 2016 deals with water and sanitation challenges in regard to climate change.

11. What is your recommendation on sustainable water supply in your village?

- Recycling waste water
- The water and sewerage system of Kisumu was designed for 19% of the current population in Kisumu, therefore there is need for more investments in this and water harvesting structures for future use.

Key informant interview 8

Name……Shadrack Owino……. Date……23/11/16……

Organization…Mbeme Chief elder…….

1.What is your perception of climate change in urban informal settlements?

- The perception of climate change in this area is drought

2. How do people in these settlements access climate change information?

- Through Radios and Barraza's

3. What is the main source of water in the area?

- The main source of water is the Nyamasaria river and then followed by KIWASCO water

4. What are the main uses of water?

- Domestic purposes and livestock rearing

5.What is the major cause's water supply shortage in the settlements?

- Dry spells
- Water pollution, water contamination is very high during rainy season

6. What are the general water-related problems in this area in Wet/Dry periods?

- Water scarcity is the major challenge during dry period, you cannot plant crops and it has affected food security.

- No income is generated during these periods.

7. How should the community deal with the water shortage challenges?

- Communities should be supported by the government and the government should increase water kiosks and water pumps.

8. Are there strategies that have been put into place to manage climate extremes and the availability of water to ensure sustainability for the future?

- The communities dig trenches
- There are evacuation points in schools and churches.
- Government has provided mosquito nets and water guard.

9. Who is responsible for water management of the municipal council water sources?

- KIWASCO

10. Are there any water supply and sanitation policies in place that deal with climate change?

- There are no policies which directly deal with climate change in water and sanitation sector

11. What is your recommendation on sustainable water supply in your village?

- The government should supply the communities with big pipes because of the growing population and appropriate water supply infrastructure.

APPENDIX C: FOCUS GROUP DISCUSSION

Focus Group Discussion 1

Location……Obunga……Date……31/06/17……
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Group composition: Male……9…….
Female……7…….

1. What is your main source of water in the household?

- KIWASCO piped water
- Borehole
- rain water
- Spring water (not treated) near Kudho primary school

1. What is the main use of water?

- Cooking
- Washing
- Drinking
- Planting
- Construction
- Car wash
- Brewing illicit brew (local whisky)
- Raring domestic animals
- Flushing toilets
- Cattle Dip
- Molding bricks

2. What are the general water-related problems in this area following Heavy Rains and Dry periods?

3a) heavy rains

- Water enters in the houses approximately up until one meter.
- Children and adults drown in nearby rivers like river Kisat about 6- 10 people have died trying to cross the river last year.
- High incidence of water borne disease is experienced during this time e.g. cholera, pneumonia, malaria, diarrhoea and TB has been found prominent.
- When there is heavy rain there is a lot of water contamination and flood water collects all waste.
- During this time, the communities spend a lot of money in hospitals for treatment.

- Flood water destroy plantations, domestic animals die, the social amenities are not easily accessible even children have to miss school
- At this time of heavy rains snake bites are frequent and the population of frogs increases.

3b) Dry Periods

- Disease such flu, cholera, eye problems (white mucus around the eyes).
- Air pollution because of lack of drainage waste accumulates in one area.
- Spring water dries up and there is limited water supply.
- The community can bath with one litre of water because of water shortage.
- Shops hike prices for food sometimes you can buy 10 shillings for a leaf of green vegetables.
- Dust storms trigger jiggers in the area.
- Animals die because of lack of pasture.

1. What is your perception of climate change in urban informal settlements?

- Drought
- Morning dew and weather pattern change
- Change of patterns of rain,
- Changes of body temperatures
- lack of water during drought

2. How do people in these settlements access climate change information?

- Media channels (Radio, TV, Facebook).
- The community uses indigenous knowledge- before drought happens it is cold during the morning for a period of one month.
- When wind pattern changes, it is a sign of drought.
- When you hear crocking of frogs it's a sign of heavy rain.

- Trees shed their leaves before drought.

3. Do climate extremes affect your livelihoods and how?

- It affects the standard of living because of high food prices.
- Poor harvest for farmers in times of drought.
- Flooded pathways may make them not to go to work.
- Informal businesses close during heavy rain.
- Fish business is low because fish is in abundance during rainy season.
- Food prices fluctuate especially for people who sell vegetables.
- It is difficult to predict planting season for farmers.
- Water vendors do not have business during heavy rains because people harvest water from their roof tops.

4. How do devastating floods affect water supply you in your area?

- Water quality is affected because flood water is contaminated with waste and there is poor drainage.
- Water supply is in abundance but clean water is hard to find.
- The water is dirty because of poor drainage and pollution from the industries.

5. How do droughts affect water supply in your area?

- Water is scare.
- Water becomes very expensive to buy.
- KIWASCO rations water.
- There is water conflict at water points with women fighting.
- Travelling long distances in search of water.
- Springs dry up.

6. To what extent do extreme events damage critical infrastructure for water supply?

- Floods causes' piped water bursts, the floods expose these pipes.
- There is massive soil erosion which fills up boreholes and there is no access to water
- Pipe leaks can get in contact with waste water.
- High temperatures destroy the pipes, the pipes are plastic PVC and they can only tolerate a certain temperature
- When the pipes break, it might take 2-3 days for KIWASCO to fix the problem.

7. What diseases are experienced by the household members following climate extreme events?

- Cholera, typhoid, diarrhoea, malaria and flu

8. How many days per week is the water supply available from your main source?

- Water is accessible about 4 days during rainy season and during dry periods it is available 2- 3 days a week.

9. How long does it take you to get to the closest access to clean water?

- It takes 10 minutes during normal days and 1 hour during dry periods.

10. What measures have you taken to place to manage shortage in clean water supply?

- Storage tanks
- Super drums
- Jerry can storage
- Clay pots storage
- CBO water tanks

11. What measures have you taken to treat water?

- Boiling
- Filling water in transparent plastics and exposing them to sunlight the whole day
- Water guard

12. What is your recommendation on sustainable water supply in your village?

- Building storage water tanks for each house
- Digging Boreholes
- Alternative supply for KIWASCO water
- Build Underground tank

Focus Group Discussion 2

Location.....Manyatta B-
Mbeme.....Date.....1/06/17.....

Group composition: Male……10…….
Female……6…….

1. What is your main source of water in the household?

- River Kibos (mostly used especially if they do not have money to buy water)
- Stagnant water pans
- Shallow wells
- Rainwater harvesting during rainy season
- KIWASCO tap water

2. What is the main use of water?

- Washing
- Household use
- Bathing
- Drinking (River/Tap water)
- Cattle raring
- Gardening
- Construction
- Smearing the house walls

3. What are the general water-related problems in this area following Heavy Rains and Dry periods?

3a) Heavy Rains

- Soil erosion.
- Crops are destroyed and there is no harvest for people who practice agriculture.
- Stagnant waters are breeding grounds for malaria.
- Snakes become more frequent.
- Toilets sink during flooding which have been dug 10 m deep.
- The housing infrastructure is destroyed.
- Disease such as cholera, malaria, bilharzias, Pneumonia are prominent
- The roads are destroyed, and people will be wading in water and general movement is difficult the area becomes inaccessible.
- The water comes up from the ground (seepage).
- There is foot rot disease which are common in the area

3b) Dry Period

- Water scarcity
- Starvation and malnutrition
- Food insecurity
- Crops and plants wither
- Domestic animals die
- High temperatures cause water pans to dry
- Soil is cracked and ragged
- Walking long distance in search of water. Normally they go to fetch water from 10pm- 2am before the cows urinate in the river water.
- The Kibos river is heavily polluted because the water levels are low and in addition the color of the water is (green, black or brown) in color with bad odor.
- KIWASCO water pressure is very low.
- A jerry can of water costs 20 shillings.

4. What is your perception of climate change in urban informal settlements?

- Weather changes which causes so much disease especially to children.
- Climate change affects farming.
- Unpredictable weather patterns.

5. How do people in these settlements access climate change information?

- There is no proper source of climate information a few people get access to the information who have radios, TV and through chiefs Barraza.
- The Met services predictions are not accurate they can tell the community to move to higher ground and there are no heavy rains the community tend to ignore the Met services warnings.
- The chief district commissioner passes information to the community for preparedness
- The community knows the history of the place is a flood zone.

6. Do climate extremes affect your livelihoods and how?

- General movement is not easy and some community members cannot go to work
- When the temperatures are very high the communities also find It hard to go to work because they cannot sleep at night and therefore they are also very tired to go to work.
- The climate extremes affect their financial plans and use of money because they spend more money on medication to cure climate related disease. The standard of living becomes too high for them.
- No harvest for farmers.

- Water kiosk also lose business.

- Vegetable vendors have to go as far as the rift valley in search of far produce to sell

7. How do devastating floods affect water supply you in your area?

- During heavy rains if KIWASCO water pipes burst the water is contaminated and because of water seepage and overflow of toilets stagnant waters are also affected.

- Water vendors have no access to road networks to sell water during flooding and they have no customers

- During flooding, there are a lot of death cases because of flood, which requires a lot of monitoring for children, they are mostly affected when going to school.

- Transport hikes to 100 shillings or more for children to go to school.

8. How do droughts affect water supply in your area?

- Water becomes expensive up to 30 shillings per jerry can.

- The community has to pack water for their children during drought period because the school taps have no water.

- Shallow wells turn salty during dry season and they can also dry up.

- Dust storms are frequent during this time.

9. To what extent do extreme events damage critical infrastructure for water supply?

- Those urban informal settlement residents who do not get water legally cut water pipes which contaminates the water.

- The pipes expand because of high temperatures, causing leakage.

10. What diseases are experienced by the household members following climate extreme events?

- Cholera
- Malaria
- Bilharzia
- Pneumonia
- Colds /Flu
- Nose bleeding (high temperatures)
- Asthma
- Typhoid

- Amoeba (Flood)
- Typhoid (Drought)
- Eye problems because of dust storms

11. How many days per week is the water supply available from your main source?

- During drought period, it is available 3-4 days a week.
- During flooding, it is available all the days.
- Unless there is a pipe burst the community can go without water for the whole month.

12. How long does it take you to get to the closest access to clean water?

- During dry period, it takes up to 4hours in search of water.
- During rainy season, it takes 30mins - 1 hour in search of water.
- The first rains are not clean.
- On normal days depending on the distance to the water source in 5-10 mins you can access water

13. What measures have you taken to place to manage shortage in clean water supply?

- The community has gone to KIWASCO to acquire for connection though the process has taken time.
- Water storage in jerry cans
- Digging shallow wells
- Using alternative sources

14. What measures have you taken to treat water?

- Water guard
- Boiling
- Chlorine
- Sun treatment
- Filtration

15. What is your recommendation on sustainable water supply in your village?

- Investing in water storage tanks.
- Acquiring piped water from KIWASCO.
- Acquiring Super drum containers 100litres.

- Getting together as a community and drilling a Borehole at a central place with proper management.
- The river can be a sustainable source by building a dam at river Kibos and have a management system for dumping.
- If an NGO can transform the natural sources

Focus Group Discussion 3

Location......Nyalenda..... **Date**.....02/06/17.....

Group composition: Male……10…….
Female……5…….

1. What is your main source of water in the household?

- Wamulanda water company which has been subcontracted by KIWASCO
- Shallow wells 4-5metres deep
- Rain water
- Auji/Nyamasaria River

2. What is the main use of water?

- Farming
- Gardening
- Construction
- Domestic use
- Drinking

3. What are the general water-related problems in this area following Heavy Rains and Dry periods?

3a) Heavy Rain

- Toilets overflow.
- The water enters the houses to about a height of a quarter of a meter.
- The ground is wet and it brings sanitation problems.
- Diseases such as diarrhea, cholera, pneumonia, malaria, meningitis are common during this time.
- Water from KIWASCO comes with sewage and has a bad odour.

- The WHO used to bring bilharzias tablets during this flooding.
- Snake bites are common during flooding.
- The water which comes from Kajulu hills can flood Nyalenda area because it is low-lying.
- Bed Bugs are also a nuisance in times of flooding
- Death of children because of exposed electric wires underground which are illegally connected and are exposed by flooding.
- Road accessibility is difficult
- The old pipes are broken and KIWASCO needs to repair when broken
- Flooding has caused a lot of death especially late 2016

3b) Dry period

- There is water conflict amongst the residents during this time and a lot of competition for water
- KIWASCO rations water during dry periods the residents can spend a week without water and the water is not enough for their domestic animals
- Herdsmen look for pasture in long distances
- High temperatures also cause fire outbreaks in the dry season
- Food insecurity

4. What is your perception of climate change in urban informal settlements?

- Climate change is a global issue and which is contributed by greenhouse gas emissions and cutting down of trees and burning of charcoal contributes to climate change
- Climate change causes global warming
- Pesticides affect climate change.
- Climate change causes dehydration in human beings.

5. How do people in these settlements access climate change information?

- Vernacular radio, TV, Newspaper Facebook, Drama has been a useful tool to communicate issues regarding climate change.
- Indigenous Knowledge system is used to predict heavy rains and droughts through

sneezing, weak body mainly in the elderly people of the community.

- The early warning signs of the community are:
  - Dropping of leaves - symbolize rains
  - Birds flocking together- symbolize Rains
  - Crooking of frogs- symbolizes rain
  - Woodpecker's - symbolize rains

6. Do climate extremes affect your livelihoods and how?

- In dry season, you spend a lot when buying food stuff to sell and double the price.
- During flooding, you cannot go to work because there is no business.
- It is difficult to go to work especially if you do not have a medical insurance plan.
- (*Achia*) water emerging from the ground makes the community sick.
- Vendors cannot sell during this period.
- Bars close early because they have no business.

7. How do devastating floods affect water supply you in your area?

- Water pipes are exposed during flooding and are burst by vehicles passing which contaminates water sometimes the water has tape worms and red in colour.
- Sometime the water is brown in colour.
- Typhoid is prominent during this period.
- There is high water pollution during this period.

8. How do droughts affect water supply in your area?

- KIWASCO rations water the residents can go 3 days without water.
- Water levels go down.
- Domestic animals die.
- Trees wither.
- People steal water meters which is a major challenge of water shortage.

9. To what extent do extreme events damage critical infrastructure for water supply?

- Flooding exposes water pipes and the water pipes breaks and it takes time for the water pipes to be repaired (about 1-2 weeks). KIWASCO feels that the community is not responsible to take care of the pipes.
- Water brokers can contribute to pay KIWASCO to fix the pipe burst.
- Extreme heat expands and breaks the pipes.

10. What diseases are experienced by the household members following climate extreme events?

- Diarrhoea, worms, bilharzias, amoeba, malaria, pneumonia, heat rush, foot rot and skin peeling

11. How many days per week is the water supply available from your main source?

- During normal days' water is available though it may not be clean.
- Pipe burst ca take 1-2 weeks without being repaired.
- During drought water is available 2-3 days of the week.

12. How long does it take you to get to the closest access to clean water?

- To access clean water, it can take 5-10mins during rainy season
- During dry period, it can take 4 hours in search of clean water and because there are long queues at the water points it takes long.

13. What measures have you taken to place to manage shortage in clean water supply?

- "We get water from Nyamasaria and we treat it."
- The community raised concerns to the chief about water shortage and they act by contributing to extending water pipes as groups.
- Community water tanks.
- (Busy Bee youth group) gave the community tanks which supplies for only 3days though the management of water is not good.
- Much has not been done to manage water supply and it is something the community has to worked on.

14. What measures have you taken to treat water?

- "God has blessed us with water so we drink it like that."
- Water guard

- Boiling
- Filtering using cloth
- Sometimes you cannot treat because the water has too much chlorine

15. What is your recommendation on sustainable water supply in your village?

- KIWASCO should extend water pipes, the cost of extending the pipes is expensive a program to extend pipes in instalments would help the community.
- KIWASCOshould install water tanks to store water and deploy youth to be water vendors
- Construction of boreholes in the area would sustain the water supply.
- Practical action has tried to build deep wells from springs.