KISUMU COUNTRY CLIMATE CHANGE VULNERABILITY ASSESMENT REPORT

REPUBLIC OF KENYA

THE COUNTY GOVERNMENT OF KISUMU

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ABBREVIATIONS

AMCEN	African Ministerial Conference on Environment
AECB Ltd	Asben Eco-Consultants and Capacity Building Limited
BPS	Poverty Benefit Scheme
CADP	County Annual Development Plan
CEC	County Executive Committee Member
CIDP	County Integrated Development Plan
COP	Convention of parties
FGD	Focused group discussion
GBV	Gender-based violence
GCCA	Global Clean Cooking Alliance
GCMs	Global Climate Models
GIS	Geographic Information System
ICT	Information Communication Technology
IPCC	Intergovernmental Panel on Climate Change
KIIs	Key informant interviews
KIWASCO	Kisumu Water and Sewerage Company
KMet	Kenya Meteorological Department
LPG	Liquefied petroleum gas
LVB	Lake Victoria Basin
ODK	Open Data Kit
NDMA	Department of Disaster Management, National Drought Management Authority
NDVI	Normal Difference Vegetation Index
NGOs	Non-Governmental Organizations
PCCB	Paris Committee on Capacity Building
SACCOs	Savings and Credit Co-Operative
SDGs	Sustainable Development Goals
SOPs	Standard operation procedures
TI-Kenya	Transparency International, Kenya
TV	Television
UN	United Nations
WHO	World Health Organization

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EXECUTIVE SUMMARY

In the Kano plains, yearly flood-related losses are estimated at US$ 850,000 (Masese et al., 2016), while relief needs amount to US$ 600,000. Such events represent significant barriers to food security and poverty alleviation efforts in the County.

Vulnerability is defined as the degree to which a human or natural system is susceptible to, or unable to cope with, adverse effects of climate change. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

The Lake Victoria basin is known for its rich biodiversity, but environmental degradation and climate change pose a significant challenge to its very existence. Environmental pollution and unsustainable/unregulated resource use have significantly contributed to the ongoing biodegradation, with hundreds of species, both aquatic and terrestrial going extinct. The situation is further exacerbated by the changing climate, characterized by prolonged drought and periods of intense rainfall and flooding. These changes are negatively impacting on livelihoods and human wellbeing. Over 10 per cent of the basin's population is gradually becoming chronically food insecure, requiring support for both short-term emergency food relief and sustainable long-term development programs. Addressing the current challenges from recent and future climate change will be challenging.

Climate Change has multiple effects on livelihoods, animal and plant health, the environment as well as ecosystem stability and resilience. Studies done in several countries show that many people are aware of health and environmental threats posed by climate variability.

It is against this background that Kisumu County undertook to develop its climate change policy, which was completed in 2018. The goal of the policy is to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Kisumu County towards climate resilience, blue economy and green development pathway. To adequately implement the policy, the County Government of Kisumu through the support of Transparency InternationalKenya (TI-Kenya), commissioned the vulnerability assessment of the County. The study was conducted by Asben Eco-Consultants and Capacity Building Limited (AECB Ltd) between February 3, 2020 and February 22, 2020.

The study's aim was to develop a comprehensive picture of current and future climate change risks as well as further stress factors to be expected. It will form a basis for adaptation planning for the county government and lead to a more transparent, accountable and effective channelling of climate finance. Adaptation cannot be planned solely based on climate projections. Information on risk and vulnerabilities is also needed to determine how the climate interacts with socio-economic issues.

Objectives

1. To identify priority issues for adaptation planning by elucidating the current and future vulnerabilities to support,
2. To identify opportunities and challenges for strengthening the adaptive capacity of the communities and building resilient systems.

METHODOLOGY

The study adopted a mixed-method approach where both primary and secondary data collection methods were used to gather data needed for the vulnerability assessment. Secondary data sources such as relevant program and sub-sector documents, county databases and related literature were used. Primary data were collected from sampled households in the County, focused group discussion (FGD), key informant interviews (KIIs) and field observation. The survey was conducted in February-March 2020 and was structured and managed in a way that ensured high data quality.

Using the standard Cochran formula for sample size calculation and considering the number of target household, a total of 427 respondents were picked, which included 5% for non-respondents samples were interviewed. Focus Group Discussions (FGD) was

conducted in 20 out of 33 wards. In addition, key informant interviews were conducted with key county government officials.

KEY FINDINGS

Development goals of Kisumu County are primarily at risk from the impacts of climate change. These impacts are already becoming a severe burden to the County's economy and its people. The risks of changing climate in Kisumu County is already being felt in the extended and frequent drought, frequent flood and raising temperature. These risks have affected agricultural production causing food insecurity and growing poverty, low per capita water availability and host of socio-economic impacts such as disease outbreaks and epidemics, and access to education facilities, among others.

Current climate change is extremely rapid, which places additional stress both on the capacity of ecosystems to adapt and on the lifespan of infrastructure. In health a combination of projected changes in climate-related exposures (e.g., temperature, precipitation, lake-level rising) reported in this study will result in amplification of existing health risks and introduction of new risks with a high degree of spatial variability. Agriculture were observed to be the most vulnerable sectors which is mainly due to drought, raising temperature, flood, and emergence of numerous diseases and pests. Climate change is, therefore, projected to compromise agricultural production, especially in smallholder systems with little adaptive capacity, as currently prevalent in many parts of county.

The increasing changes in climate will pose challenges for the County's development aspirations. With continued increases in greenhouse gas emissions, the atmosphere and oceans will warm, rainfall patterns will change, the frequency of drought and flood incidences will increase, all these changes serve to increase the challenges to Kisumu's development. The loss of environmental assets due to climate change will affect many people and the economy with devastating effects on people, their culture, and their livelihoods.

Based on the overall observation in different sectors

Overall vulnerability by sector

Sector	Flood	Drought	Rising Temp	Changing rainfall patterns	Diseases and pests	Lake level rising	Invasive species	Overall vulnerability
Agriculture &Livestock	x	x	x	x	x	x	x	
Water	x	x		x	x	x	x	
Environment	x	x	x	x	x	x	x	
Health	x		x		x	x		
Roads and transport	x			x		x	x	
Sewage	x			x	x	x		
Market	x				x			
Education	x				x	x		
Technology	x							
Energy	x	x			x			
Housing	x		x		x	x		

Overall vulnerability by sub-count

The study has demonstrated that all sub-counties are vulnerable to climate change. The key vulnerability factors (**exposures**) include drought, rising temperature, climate related diseases and pest, lake level rising and invasive species. The key factors that makes the country vulnerable to the exposure (**sensitivity**) factors include high level of poverty, settlement patterns, poor land management practices, use of poor-quality crop and animal breads, growing population, among others. Further the study has demonstrated evidence of low **adaptive capacity** in the County. The combination of the three factors has caused high vulnerability in the County.

Sub-county	Flood	Drought	Rising Temp	Climate-related Diseases and pests	Lake level rising	Invasive species	Overall vulnerability
Kisumu Central	x		x	x	x	x	
Kisumu East	x	x	x	x	x	x	
Kisumu West	x	x	x	x			
Seme		x	x	x	x	x	
Muhoroni	x	x	x	x			
Nyando	x	x	x	x	x	x	
Nyakach	x	x	x	x	x	x	

Key

Low (1-2 factors)	Medium (3-4 factors)	High (5-6 factors)

MAJOR INTERVENTION AREAS TO ADAPT TO CLIMATE CHANGE

1 Housing and Settlement in Safe Areas

Current settlement trends in the County lead to unplanned development, including in areas with significant and increased levels of natural risks such as flood-prone areas, wetlands and Lakeshores. To address the problem, the study recommends the following measures:

i. Develop a comprehensive digitalized spatial plan for the whole County to control and prevent development in unsafe areas and reduce vulnerability of settlement areas.
ii. Partner with the provider sector to provide safe and affordable housing solutions in the County
iii. Work with the private sector to strengthen the quality and availability of affordable local construction and building materials industry.
iv. Assess the efficiency of the rental market and work to ensure that it meets the needs of the extremely poor.
v. Upgrade informal settlements for current and future risks by adopting a passive planning approach for in situ upgrading of the settlements

2. Strengthened Infrastructure to Meet the Needs of the County Economy and Population

Infrastructure specifically designed to reduce vulnerability to climate variability (e.g., flood control structures and decentralized energy systems) and general public health infrastructure (e.g., sanitation facilities, wastewater treatment systems, laboratory buildings) enhance adaptive capacity. However, infrastructure (especially if immovable) can be adversely affected by climate, especially extreme events such as floods. Based on the findings, the study recommends:

i. The County to investments in flood risk management such as dykes, riverbank training and drenching, etc.;
ii. Desilting of rivers and streams;
iii. Drilling of more boreholes;
iv. Digging of canals to direct water to the lake;
v. Extending piped water provision households;
vi. Shoreline protection measures through legislative means and protection walls where necessary;
vii. Invest in resilient road network to critical installations and services such as schools, health facilities, market etc.;
viii. Improve water transport by addressing safety issues, impact of water hyacinth and necessary by-laws;
ix. Build/strengthen energy systems for climate resilience and enhance access to clean energy by the poor;

x. Improve water and sanitation services especially in the informal settlement, peri-urban and rural areas;
xi. Improve health infrastructure by reducing the average distance to the health facility, number of health service providers and relevant supplies. Community health volunteers play a critical role in providing health services in rural areas;
xii. Completion of the health facilities construction such as Ugwe, Kanyagila, Komwaga, Ogenya and Reru.
xiii. Improve access to technology such as smart mobile phones to support agriculture, water resources and health-care systems;
xiv. Invest in education infrastructure;
xv. Construction of footpaths along rivers that connect wards; and,
xvi. Construction of more toilets in schools.

3. Support Climate Smart Agriculture and Fisheries Development to Drive Sustainable Economic Development

If farmers and fishers are enabled to adapt to weather threats and climate extremes in the short and medium-term, future generations will be better placed to adapt to climate change, whatever specific form it takes. Measures that improve productivity while also building resilience to future climate change are generally referred to as “no-regret" measures—that is, actions that make sense even in the absence of climate change. The study recommendations:

i. Promote/Provide farmers with climate-resilient crop varieties and animal breeds;
ii. Build the capacity of farmers to adopt sustainable soil management;
iii. Support renewable energy-based efficient irrigation technologies;
iv. Promote/support improved climate-resilient fishery technology such capture fishery system;
v. Develop and implement agriculture insurance programs to manage the financial cost of disasters to farmers and government;
vi. Provision of farm inputs by the county Government;
vii. Employment of Agricultural extension officers to advise farmers on correct farming methods;
viii. Construction and provision of water reservoirs for irrigation;
ix. Provision of market for farm produces;
x. Cold and storage facility for fish

xi. Promote integrated pest management; and,
xii. Promote sustainable agricultural systems such as agro-forestry.

4. Environmental Protection

The combined effect of growing population and impacts of climate change has a significant pressure on the environment resulting in environmental degradation causing serious challenges such poor land use planning, lack of proper liquid and solid waste management; unregulated point and non-point source pollution; dropping water levels; Increase in silt loads entering the lake; catchment degradation (Land and forests); lack of protection of wetlands; and loss of biodiversity and ecosystem services.

Kisumu's economy is resource-based relying heavily on farming, fisheries as well as for related livelihoods. Disruption of this system, therefore, has led to severe problems. For example, land degradation results in low food production and increased poverty. Strengthening and enforcement of environmental governance is, therefore, a key to long-tern resilience building. The study recommends:

i. To build on the existing Kisumu Environment Policy, the County needs to develop and implement strong environmental legislation, which is essential to minimize further degradation of the ecosystems and ensure their continued protection;
ii. Develop and implement a clear action plan to preserve soil and soil fertility, including through training and capacity building of communities, in order to maintain agriculture production for food security and livelihoods;
iii. Investments in community-led protection of forest, wetland, lakeshore, and riverbank areas;
iv. Develop and implement a comprehensive waste management policy and strategy to reduce pressure on the environment and ecosystems;
v. Conserve protected areas to withstand increasing pressures and effects of changing climate;
vi. Invest in eco-tourism.

5. Build Socioeconomic Resilience to Take Care of the Poor and Keep Economic Growth Inclusive

For vulnerable and low-resilience populations, it is critical to provide the tools and support they need to manage and recover from the natural shocks that cannot be avoided. Indeed, appropriate land-use planning and building norms, as well as better

infrastructure, can help minimize the risk that natural hazards like heavy precipitation will translate into natural disasters, but they cannot prevent all shocks. Some shocks are unavoidable, especially in highly exposed areas. Moreover, the County will continue to have a share of its population at high risk and with limited capacity to cope with and recover from shocks. This population will remain dependent on government and community support after disasters.

Similarly, people stuck in low-income activity will need support to benefit from economic growth. Growing sectors can provide new and higher-productivity jobs, but vulnerable populations may struggle to capture those opportunities and risk being locked into low-productivity or decreasing productivity jobs and activities. For those, dedicated policies are needed to improve their wellbeing, help them capture opportunities and accumulate assets, and ensure that their children do not inherit poverty and vulnerability from their parents.

The study recommends thus:

i. Establish an effective early warning system and preparedness to save lives and protect assets;
ii. Establish a social protection including Insurance-based solutions to make the population better able to cope with shocks;
iii. Improve the health care system to improve resilience and build capacity to prepare for climate change-induced health emergencies;
iv. Ensure Equity by providing targeted gender interventions and specific measures to protect vulnerable populations in all sectors, including prevention gender-based violence (GBV).

6. Nurture Evidenced-based Decision Making, Private Sector Participation and Capacity Building

Designing a resilience strategy for the County would require constant data supply, and the use of these data for evidence-based decision-making, in particular regarding new investments and maintenance prioritization. The study recommends:

i. Provide a framework for continuous data collection and analytical work;
ii. Create a framework for climate financing and private sector participation; and,
iii. Build capacity of stakeholders and enhance community awareness on climate change risks and adaptation.

1. INTRODUCTION

1.1 Background

Climate change is globally acknowledged as one of the most significant development challenges facing humanity. There is increasing evidence that climate change is directly affecting the social, economic and human development of countries. Combating climate change, therefore, has become one of the key global development priorities.

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) presents strong evidence that surface temperatures across Africa have increased by 0.5-2°C over the past 100 years, and from 1950 onward climate change has changed the magnitude and frequency of extreme weather events. Africa is one of the most vulnerable continents to the impacts of climate change[1]. From the local level to the global, climate change has, therefore, become an economic, political, social, and environmental challenge, and Africa is especially vulnerable to its adverse effects. This is contributed by the fact that most of the continent's economies depend on climate-sensitive natural resources and have very low levels of adaptive capacity and extreme levels of poverty.

Kenya's climate is already changing. Average annual temperatures increased by 1°C between 1960 and 2003, with most warming taking place in the 'long rains' season of March, April and May, which is also the primary planting season[2]. The effects of climate change and related disasters have the potential to impact the majority of Kenyans adversely, given that about 75% of the population depends directly on land and natural resources for their livelihoods. In recent years, there has been increased attention to climate change due to its impacts on the lives of Kenyans. This has been mainly due to an increase in intensity and frequency of extreme climate events such as severe droughts and flooding. These extreme events have had negative socio-economic impacts on almost all sectors in the Kenyan society such as health, agriculture, livestock, environment, hydropower generation, and tourism. The seriousness of the problem has

[1] Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007: 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
[2] UNCCD (2010). Climate change in Kenya: Focus on children.

made it imperative for policymakers to begin to mainstream climate change in development policies and strategies.

In Kenya, climate change has increased the frequency and magnitude of extreme weather events that have led to loss of lives, diminished livelihoods, reduced crop and livestock production, and damaged infrastructure, among other adverse impacts. Climate change is likely to negatively impact Kenya's future development and achievement of the goals of Kenya's Vision 2030 – the long-term development blueprint – and the Government's Big Four agenda for 2018-2022, which focuses on ensuring food, and nutrition security, affordable and decent housing, increased manufacturing and affordable healthcare.

Among the most vulnerable regions in Kenya is the Lake Victoria Basin. Recent socio-economic impacts of severe and prolonged droughts in the Lake Victoria Basin (LVB) states demonstrate the sensitivity and vulnerability of local populations[3]. Over 10 per cent of the basin's population is gradually becoming chronically food insecure, requiring support for both short-term emergency food relief and sustainable long-term development programs.[4] Addressing the current challenges from recent and future climate change will be challenging.

Climate Change has multiple effects on livelihoods, animal and plant health, the environment as well as ecosystem stability and resilience. Studies done in several countries show that many people are aware of health and environmental threats posed by climate variability. In the Lake Victoria Basin (LVB), effects of climate change are increasingly being recognised as a significant factor contributing to poverty because of its implication to agriculture and food security, water resources including ecosystems goods and service as well as its' direct and indirect effects on human health.

The negative impacts of climate change will increasingly be felt in the waters and on the shores of Lake Victoria. Inter-annual and inter-seasonal variability in rainfall and temperature could affect the survival of aquatic life, increasing the variability of fish

[3] Awange JL, Aluoch J, Ogallo L, Omulo M, Omondi P (2007) An assessment of frequency and severity of drought in the Lake Victoria region (Kenya) and its impact on food security. Climate Res 33:135–142.
[4] Lake Victoria Basin Commision (2018). Lake Victoria Basin Climate Change Adaptation Strategy and Action Plan 2018–2023

catches, while uncertain agricultural yields inland may bring new entrants into the fishery each year. According to a study by Awange, et al. (2013)[5] a combined impact of both climate change and other anthropogenic factors has affected LVB water storage and led to a decline in fish and access to fresh water, environmental scarcity, loss of livelihoods, poor health and food insecurity.

1.2 Kisumu Country

1.2.1 Location and Size

Kisumu County lies between longitudes 330 20'E and 350 20'E and latitude 00 20' South and 00 50' South. The County borders by Homa Bay County to the South, Nandi County to the North East, Kericho County to the East, Vihiga County to the North West, Siaya County to the West and surrounded by the second-largest freshwater lake in the World; Lake Victoria. Kisumu County covers approximately 567 km^2 on water and 2086km^2 land area, representing 0.36% of the total land area of Kenya's 580,367km^2. The County has a shoreline on Lake Victoria, occupying northern, western and a part of the southern shores of the Winam Gulf.

The County has a diverse background comprising of urban and rural set-ups as well as rich ethnic, racial and cultural diversity with the Luo being the dominant community. The County's strategic position serves as a gateway for Kenya into the rest of the African Great Lakes region. It is located on the shores of Lake Victoria and serves as the main commercial and transport hub for the Western part of Kenya and the East African region. The County hosts the third-largest city in Kenya, Kisumu city, which serves as the County's headquarters. There are five major urban centres; Ahero, Katito, Muhoroni, Chemilil, and Maseno. Other emerging fast-growing centres include Awasi, Pap-Onditi, Holo, Kombewa and Sondu.

1.2.2 Demographics

Kisumu County is home to 1,155,574 (according to the 2019 National Census). The County has 300,745 households with average household size being 3.8 and the average population density of 554 persons per Sq. Km (Table 1).

[5] Awange J. L., Anyah R. Agola N. Forootan E. and Omondi P. (2013). Potential impacts of climate and environmental change on the stored water of Lake Victoria Basin and economic implications. Water Resources Research, VOL. 49, 8160–8173, doi:10.1002/2013WR014350.

Table 1: Population of Kisumu County per sub-county Source: (2019 population census)

Sub-county	Population	Average household size	Land area (Sq. Km)	Population density (No. per Sq. Km)
Kisumu East	220,997	3.6	141.6	1,560
Kisumu Central	174,145	3.3	36.8	4,737
Kisumu West	172,821	3.7	209.0	827
Seme	121,667	4.1	267.7	455
Muhoroni	154,116	4.1	657.5	234
Nyando	161,508	4.2	446.1	362
Nyakach	150,320	4.2	326.7	460
Total/Average	1,155,574	3.8	2,085.4	554

Figure 1. Population map of Kisumu County

1.2.3 Climatic Conditions

The climate of the County is generally warm with minimal monthly variation in temperatures between 23^0C and 33^0C throughout the year. The rainfall is determined by a modified equatorial climate characterised by long rains (March to May) and short rains

(September to November). The average annual rainfall varies from 1000-1800mm during the long rains and 450-600mm during the short rains. The altitude in the County varies from 1,144 meters above the sea level on the plains to 1,525 meters above sea level in the Maseno and Lower Nyakach areas. This greatly influences temperatures and rainfall in the County[6].

1.2.4 Physiographic and Natural Conditions

Physical and topographic features

The County's topography is undulating and characterised by Kano-Plains which is a flat stretch lying on the floor of the Rift Valley, the Nyabondo Plateau and the over-hanging huge granite rocks at Riat hills, Maseno and Seme areas. Due to flash flooding, the Kano-Plains have rich alluvial soils which favour agricultural production in horticulture and rice. Granites, on the other hand, find their use primarily in the building and road construction industry. The County is endowed with the second largest freshwater lake in the world; L. Victoria with two major rivers; Nyando and Sondu-Miriu and other seven permanent rivers, Awach-Kano, Oroba/Ombeyi, Kibos, Awach-Seme, Kisian, and Mugru, in its catchment. These resources provide a big potential for the development of the blue economy. Impala sanctuary, Ndere Island, the legendary Luanda Magere and Kit-Mikayi sites are among the unique topographical features.

Ecological Conditions

Kano Plains is predominantly black cotton soil which is poorly drained and unstable though suitable for rice, horticulture and sugarcane production. Seme and the lower parts of Nyakach Sub-counties are dominated by lake sediments, commonly sand and clay soils while Kisumu West Sub-county and upper-Nyakach are predominantly red-loamy soils suitable for agricultural production. The lake shores are generally swampy and offer fertile ground for horticulture and fish breeding.

[6] County Government of Kisumu (2018). County Integrated Development Plan (CIDP) 2018-2022

2. CONTEXTUAL FRAMEWORK

2.1 Climate Vulnerability

According to the 4th IPCC Assessment Report, there is already evidence that Africa is warming faster than the global average, and this is likely to continue[7]. The warming occurs year-round. By 2100, temperature changes will fall into ranges of about 1.4 to almost 5.8°C increase in mean surface temperature compared to 1990 and about 10 to 90cm rise in mean sea level. This warming is most significant over the interior of semi-arid margins of the Sahara and central southern Africa. By the time the atmospheric concentration of carbon dioxide-equivalent has doubled, the global mean precipitation is projected to be about 1–5 per cent higher than in 1990. Africa is one of the most vulnerable continents to the impacts of climate change[8] . These adverse impacts of climate change have combined with poverty, poor policy and inadequate institutional frameworks to make the situation even worse[9].

Africa is highly vulnerable to climate change, mainly because of its strong economic dependency on climate-related activities and products and low adaptive capacity. This low adaptive capacity is linked to weak economies, weak institutions and inadequately developed governance structures. Water, agriculture, health sectors and entire ecosystems, are sensitive to changing climate, including changes in the magnitude and frequency of extreme events. The agricultural sector is sensitive to rising surface temperatures and varying rainfall, and these changes will affect the attainment of food security on the continent. Climate sensitive diseases (including malaria, meningitis, and cholera) are expected to expand to areas where they are not currently common. For example, malaria will likely expand to highland areas, where increased temperatures will make it easier for mosquitoes to breed[10].

There is a multitude of definitions and interpretations of the term vulnerability. The only consensus that seems to exist is that vulnerability is bound to a specific location and context. Vulnerability could be defined as 'the degree to which a system is susceptible

[7] Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007: 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
[8] Intergovernmental Panel on Climate Change (IPCC) (2007) Climate change 2007: 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
[9] AMCEN, 2011: Addressing Climate Change Challenges in Africa; A Practical Guide Towards Sustainable Development.
[10] African Climate Policy Centre (ACPC), 2013. Vulnerability to Climate Change in Africa: Challenges and Recommendations for Africa. Policy Brief

to and unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. Vulnerability of a country is assessed by considering six life-supporting sectors: food, water, health, ecosystem services, human habitat and infrastructure.

The Intergovernmental Panel on Climate Change (IPCC) identifies three components of climate change vulnerability: exposure, sensitivity and adaptive capacity (Fig. 2). The **exposure**: It is the extent to which the future changing climate conditions stress human society and its supporting sectors. The **sensitivity** refers to the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise). The **adaptive capacity** refers to the ability of a system to adjust to climate change – including climate variability and extremes – to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

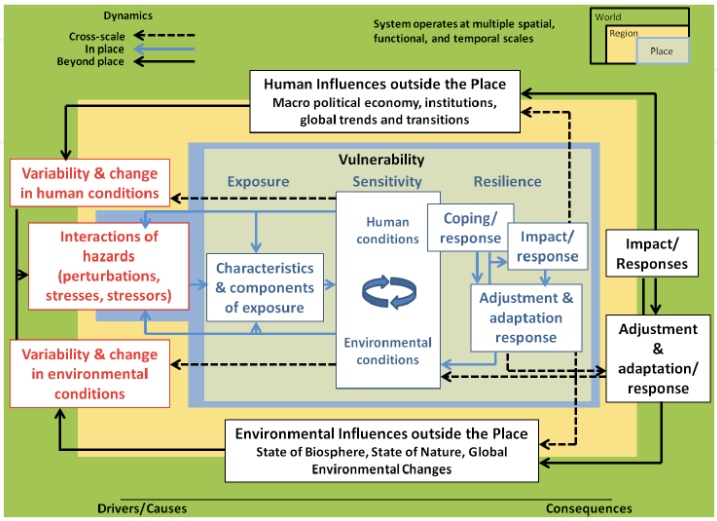


Figure 2 Vulnerability conceptual framework

2.2 Vulnerability Assessment

The adverse effects of climate change on natural and human systems are becoming more and more severe and complex[11]. This is why the question of understanding the level of vulnerability of natural and human systems has become a significant concern and a challenge for the academic, political, and development practitioners' communities. Assessing vulnerability to climate change is essential for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts[12]. It enables practitioners and decision-makers to identify the most vulnerable areas, sectors and social groups. In turn, this means climate change adaptation options targeted at specified contexts can be developed and implemented.

Importance of vulnerability assessment

- Vulnerability Assessments can support adaptation planning in several ways:
- Identify areas most likely to be impacted by projected changes in climate;
- Build an understanding of why these areas are vulnerable, including the interaction between climate change, non-climatic stressors, and cumulative impacts;
- Assess the effectiveness of previous coping strategies in the context of historical and current changes in climate; and
- Identify and target adaptation measures to systems with the greatest vulnerability.

In Kisumu County, the combined effects of climate change and rapid population growth are increasing food insecurity, environmental degradation, and increased poverty levels[13]. The growing population in the County coupled with the changing climate has resulted in severe environmental concerns. These challenges include poor land use

[11] USGCRP (2016). *Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N.Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J.Trtanj, and L.Ziska, Eds. U.S. Global Change Research Program, Washington, DC. 312 pp. dx.doi.org/10.7930/J0R49NQX.

[12] Hans-Martin Fussel (2007). Vulnerability: A generally applicable conceptual framework for climate change research. Global Environmental Change 17 (2007) 155–167

[13] Chadwick O. Ajuang1 , Paul O. Abuom1 , Esna K. Bosire1 , Gabriel O. Dida2 and Douglas N. Anyona1* (2016). Determinants of climate change awareness level in upper Nyakach Division, Kisumu County, Kenya. SpringerPlus (2016) 5:1015

planning, lack of proper liquid and solid waste management; unregulated point and non-point source pollution; Increase in silt loads entering the lake; catchment degradation (Land and forests); lack of protection of wetlands; and loss of biodiversity and ecosystem services. This situation has resulted in increased vulnerability of the communities to climate change.

While Kisumu County is known to be one of the highly vulnerable counties to climate change[14], there is very little data on vulnerability and risk levels. As a first step, available information for the country's future threats (e.g. sectoral vulnerability assessments) and opportunities should be collected and analysed. It is essential to have as much accurate information as possible about the County climate change and climate change impacts to support policy implementation and planning of development activities.

Based on the preceding, the County Government of Kisumu, supported by Transparency International – Kenya, embarked on the process of conducting a vulnerability assessment to support the implementation of the County Climate Change Policy and development of the County Climate Change Adaptation Plan.

2.3 Policy Framework

The Climate Change Act, 2016 is the primary legislation guiding Kenya's climate change response through mainstreaming climate change into sector functions, and it is the legal foundation of the NCCAP. Besides, Kenya has developed the National Climate Change Response Strategy (2010), first NCCAP (2013-2017), National Adaptation Plan (NAP 2015- 2030), Kenya Climate-Smart Agriculture Strategy (2017-2026), Climate Risk Management Framework (2017), National Climate Change Policy (2018) and National Climate Finance Policy (2018), among other sector plans and policies that address aspects of climate change.

The second NCCAP (2018-2022) aims to further Kenya's development goals by providing mechanisms and measures to achieve low carbon climate-resilient development in a manner that prioritises adaptation. This plan builds on the first Action Plan (2013-2017) and provides a framework for Kenya to deliver on its Nationally Determined

[14] Awange J.L., Aluoch J., Ogallo L., Omulo M., Omondi P. (2007). An assessment of frequency and severity of drought in the Lake Victoria region (Kenya) and its impact on food security. Climate Res 33:135–142

Contribution (NDC) under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). NCCAP 2018-2022 guides the climate actions of the National and County Governments, the private sector, civil society and other actors as Kenya transitions to a low carbon climate-resilient development pathway.

Further, the Climate Change Act 2016 provides a regulatory framework for an enhanced response to climate change, and promotes a mainstreaming approach to enhance action toward a low carbon climate-resilient development pathway. Part III, section 19 of the Act provides for mainstreaming climate change actions into County Government functions. Based on the aforementioned provisions, Kisumu County has developed a Kisumu County Climate Change Policy to mainstream climate change actions into the Kisumu County Government functions with an overall aim to ensure that climate change is mainstreamed in the economically and socially vulnerable sectors of the economy and to steer Kisumu County towards climate resilience, blue economy and green development pathway.

2.4 Objectives of the Study

The study aim was to develop a comprehensive picture of current and future climate change risks as well as further stress factors to be expected. It will also help identify opportunities arising from climate change, and provide information on how to assess adaptive capacity and cope with uncertainty.

It will form a basis for adaptation planning for the county government and lead to a more transparent, accountable and effective channelling of climate finance. Adaptation cannot be planned solely based on climate projections. Information on risk and vulnerabilities is also needed to determine how the climate interacts with socio-economic issues.

Objectives

1. To identify priority issues for adaptation planning by elucidating the current and future vulnerabilities; and,

To identify opportunities and challenges for strengthening the adaptive capacity of the communities and building resilient systems.

3. METHODOLOGY

3.1 General Approach

The survey was conducted by the County Government of Kisumu, Department of Water, Environment, Natural Resources & Climate Change. The study adopted a mixed-method approach where both primary and secondary data collection methods were used to gather data needed for the vulnerability assessment. Secondary data sources such as relevant program and sub-sector documents, county databases and related literature were used. Primary data were collected from sampled households in the County, focused group discussion (FGD) and field observation. The survey was conducted in February-March 2020 and was structured and managed in a way that ensured high data quality.

3.2 Survey Instrument Design

The survey instruments were designed to meet the objectives and obtain the information listed under the indicators. The design of the survey instruments was done to ensure that there was little variability between interviewers, thus enhancing the collection of credible data/information from the interviewees. The draft survey instruments was shared with Kisumu County and TI-Kenya for their concurrence before finalisation and roll-out of the study. The survey tool was then loaded in an Open Data Kit (ODK).

3.3 Sampling Techniques

Using the above standard sample size calculation and considering the number of target households, a total of 427 (Fig. 4) which included 5% for non-respondents' samples were interviewed. The consultant team employed a multi-stage cluster sampling technique where the sub-counties were first-level clusters and second and 3rd level clusters were the wards and sub-locations. Random sampling technique was used to select the houses for household interviews at sub-location level.

Focus Group Discussions (FGD) was conducted in 20 out of 33 wards. To compare the changes brought by the project in target beneficiaries, the selection of the groups considered gender representation. In each FGD, 6-8 people participated in the discussions. Inclusivity was ensured in the selection of the participants.

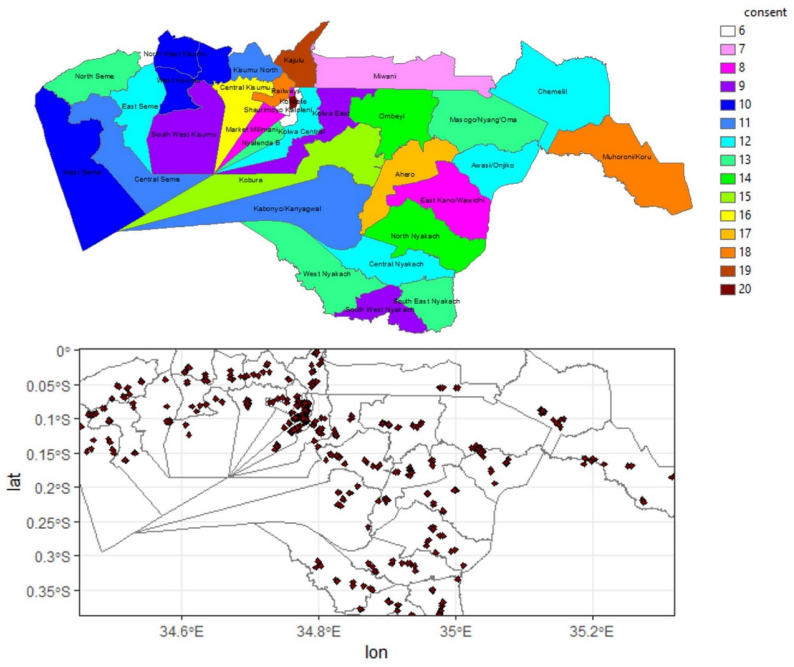


Figure 4 Map of Kisumu County showing households sampled for the interview per ward/sub-location

The study also conducted key informant interviews (KIIs) with relevant county and national government sectorial officials such Departments of Water, Health, Agriculture, Livestock, Fisheries, Environment, Climate Change, Renewable Energy Health and County Director Kenya Meteorology Department.

3.4 Data Analysis

The data collected using different instruments were analysed, interpreted and used for preparation of assessment report. The survey data were encoded, entered into the appropriate programme, cleaned and analysed. Quantitative data gathered through interviews were analysed using SPSS software with a 95% confidence level and 5% margin of error and discussed together with the qualitative data to give the overall picture of the evaluation. The quantitative data were used as the primary input for

describing the results. It was also used to enrich, complement qualitative data and illustrate the evaluation findings.

The findings from document reviews and field observations were organised and incorporated into appropriate sections of the report. The level of analysis included descriptive statistics based on measures of central tendency (including percentages, comparisons and averages) and inferential statistical analyses. Qualitative information from Focus Group Discussions complemented the quantitative information in the process of writing report.

3.5 Ethical Considerations and Quality Control

In this assignment, different data quality assurance mechanisms were employed at all stages of the evaluation process. Accordingly, the evaluation employed a participatory and voluntary approach to ensure that data collected reflected the reality of the project support.

3.6 Challenges

1. The biggest challenge that faced the exercise was poor road accessibility. The study period was planned to coincide with the usual dry month of February. However, due to the unexpected rainfall pattern, the month saw unexpectedly heavy rainfall and many roads and bridges were washed, thus causing accessibility problem in many areas. The team did its best to reach the site either on foot or using alternative means of transport such as motorbike.
2. Due to the seriousness of impacts of climate change such as flooding, the locals expected the team to provide solutions to their problem, which was beyond the scope of the study. This made some of the respondents to feel disappointed and less enthusiast in responding to the questions. Effort was made by the data collection team to clarify the aim of the study beforehand to avoid over-expectation by the respondents.

4. RESULTS: THE CLIMATE CHANGE RISK, EXPOSURE SENSITIVITY AND ADAPTIVE CAPACITY

This section attempts to capture the climate-related risks and shocks facing Kisumu County. "Risk" is used here to designate the potential of shocks and stresses to affect, in different ways, the state of systems, communities, households or individuals. Individuals, families and communities are constantly exposed to risks that can threaten their well-being. Ill health, unemployment, violent crime, or a sudden change in market conditions can, in principle, affect anyone. Climate risks are not equally distributed, but they are widely disbursed. Many factors influence the way a community or individual households react to such risks. These factors include their socioeconomic situation and environment, which affect their capacity to adapt to climate shocks which are referred to as sensitivity and the adaptive capacity.

Commented [PN1]: My understanding of this section is that it discusses the findings as per the data collected and analyzed. However, there is so much information that is descriptive of the conditions/situation in the county that is not deduced from the data collected. I would propose that that information is moved to section 1.2 so that all information relating to the description of the county is found in one section and this chapter is left only to tease out the findings as per the data collected and analyzed.

Also, one thing that doesn't come out clearly in each sector discussed is how climate change impacts the sector now and in the future. For instance, how will increasing temperatures have an impact on the water sector (access to water and quality of water) looking at both drought and floods that will increase? How will increasing temperatures impact the agriculture sector (pests, diseases, yields, agroecological zones????

4.1 Socioeconomic Profile

4.1.1 Demography characteristics

According to 2019 census, Kisumu County has a total population of 1,144,777 people with an average population density of 554 persons per square kilometre. The County has approximately 300,745 households and an average household size of about 3.8 members. The average national population density of Kenya is 82 persons per square kilometres which shows that Kisumu population is high above the average national population. Roughly 70% of the people live in rural areas, most of whom are women; rural-to-urban migration is particularly high among men, who move to urban centres such as Kisumu, Ahero, Maseno, Chemelil, Muhoroni, and Awasi, in search for off-farm jobs.

4.1.2 Education

The education level of the head of household to some extent, usually influences decisions such as the adoption of new technologies and investment levels, including the ability to take risks in making decisions. Literacy levels are relatively high in Kisumu County, where 82% of the population can read and write. Over 85% of the population can read and write and have primary education and above (Fig 5). There was a significant difference in the level of Education between the sub-counties at 95% confidence level

(p-value = 0.04929) with the highest number of respondents with higher Education coming from Kisumu Central and East (Table 2).

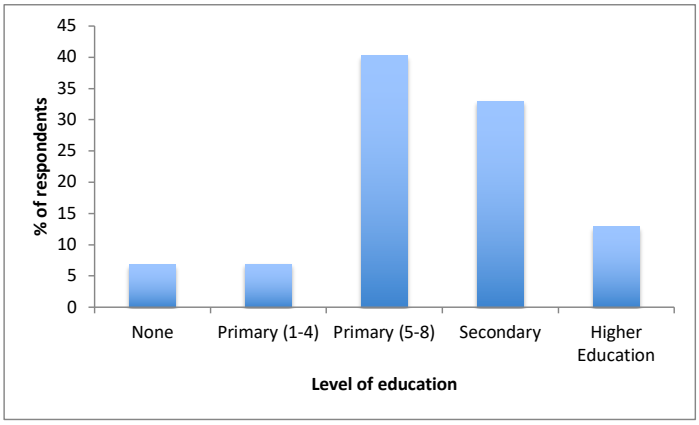


Figure 5 Level of Education

Table 2. Pearson's Chi-squared test between the sub-counties

Sub-County	None	Primary (1-4)	Primary (5-8)	Secondary	Higher Education
Kisumu East	3	4	19	18	15
Kisumu Central	6	5	25	27	15
Kisumu West	4	7	27	16	3
Muhoroni	5	2	28	20	9
Nyakach	2	4	22	26	9
Nyando	6	3	26	23	2
Seme	3	5	25	11	2
Sum	29	30	172	141	55

(Pearson's Chi-squared test; n = 427; X-squared = 36.478, df = 24, p-value = 0.04929)

Level of Education is an important factor in resilience to climate change. In a society where employment opportunities are based on Education, it is assumed that individuals with a higher level of Education have better opportunities for better-paid employment, which comes with higher levels of income. People with higher income are more

resilience to climate-induced shocks[15]. For example, in the current study, it was demonstrated that respondents with upper primary school education and above had more household assets than their counterparts with lower education levels (Fig. 6).

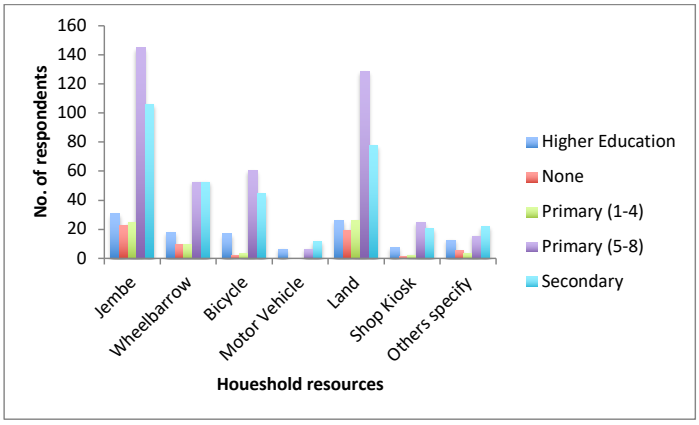


Figure 6 Level of Education and household resource

4.1.3 Household heads

The study revealed that about 71% of the households are male-headed, while 22% and 7% are female and youth headed, respectively. This observation could have a bearing on how households' vulnerability to climate change. For example, in a patriarch society where resource allocation is biased towards males, female headed households could be disadvantaged in terms of resource allocation, therefore, are in more vulnerable to climate change. Previous studies also concludes that the impacts of climate change, extreme weather events and slow-onset disasters are acutely felt along gender lines[16],[17]. Gender-based inequalities and social exclusion are vital factors undermining people's and community's capacities to cope[18].

[15] Asmamaw, M., Mereta, S. T., & Ambelu, A. (2019). Exploring households' resilience to climate change-induced shocks using Climate Resilience Index in Dinki watershed, central highlands of Ethiopia. PLOS ONE, 14(7), e0219393. doi:10.1371/journal.pone.0219393.

[16] Sultana, F. (2014). Gendering Climate Change: Geographical Insights' The Professional Geographer 66(3): 372–381.

[17] Vincent, K.E., Tschakert, P., Barnett, J., Rivera-Ferre, M.G. and Woodward, A. (2014) 'Cross-chapter box on gender and climate change', in Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R. and White, L.L. (eds.), Climate Change 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 and New York: Cambridge University Press, 105–107.

[18] with Masson V.L., Norton, A. and Wilkinson, E. (2015). Gender and Resilience. Working Paper. BRACED.

4.1.4 Household income

At least 55% of the respondents reported that they did not have a salary, regular source of income, or estimate of how much money they made per day or per month. This is likely because they describe themselves as casual workers or farmers and do not make a steady income. Casual workers are those who work on farms, drive motorbikes, or work other odd jobs, which does not allow them to estimate their regular income. A few other participants did not list income because they are retired, students, or they were women whose husbands would not share financial matters with. Majority of the respondents are either self-employed (31.4%) or farming (24.8%) (Fig 7). Fishing is one of the key economic activities in Kisumu County, accounting for 22.4% of the respondents. Most of the fish harvesting takes place in Lake Victoria. With the advent of fish ponds, households are investing in the ponds, and there are over 1,330 fish farms. Adult male-headed households had a relatively higher level of participation across all types of occupation in the County.

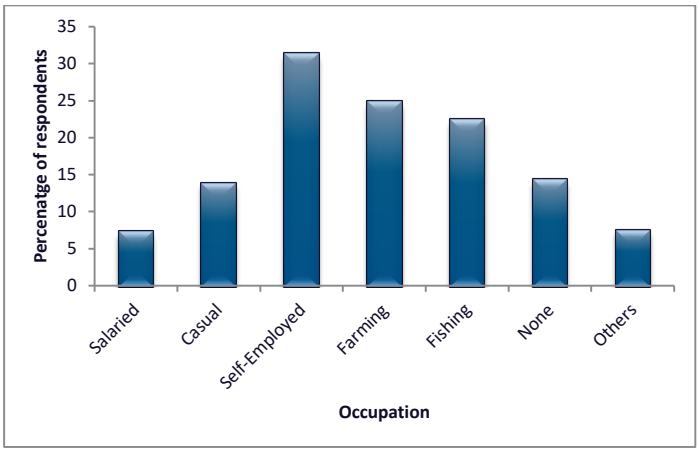


Figure 7 Main occupations

4.1.5 Land ownership

The average farm size was 3.5 acres. Disaggregated by gender, male-headed households owned 4.5 acres, female-headed owned 3.2 acres, and youth headed owned 3.0 acres. The holdings are highly fragmented, which discourages economies of scale and long-term investments. There was a significant difference (at 95% confidence level) between sub-counties on the average land size per household. Kisumu Central and East have the

smallest sizes, while Muhoroni has the highest number of respondents with more than 5 acres of land compared to other sub-counties on average. Most of the land (79%) is owned by individuals, 5% is clan/ family-owned, 0.4% is communally-owned, and the rest is owned by various local authorities. Land is a critical factor of production. Therefore, the smaller the landholding size per family, the higher the vulnerability. About 40% of households hold title deeds to their land, 53% owned land but did not have title deeds or any formal document and 7% leased land. This indicates that only about 40% of households have incentives to borrow or undertake investments using their land as collateral. The challenge of conducting climate investments on government owned land could also be affected since few or no parcels had been set aside for community projects except schools and water projects already congested due to lack of space for expansion.

4.1.6 Poverty

High poverty level is one of the significant developmental challenges in Kisumu County. The impact of climate change has further exuberated the poverty situation in the County. While climate change is a global phenomenon, its negative impacts are more severely felt by vulnerable poor in rural and peri-urban areas. In Kisumu, high dependency on natural resources as well as climate-sensitive agricultural practices are a major cause of vulnerability to climate change. The situation is further worsened by the low technical capacity of the communities and insufficient financial resources to cope with climatic extremes.

The leading causes of poverty include the HIV and AIDS pandemic, collapse of local agro-based industries, unemployment, low agricultural and fish production. Food insecurity, inaccessibility to affordable healthcare, lack of proper storage facilities, erratic and unreliable rainfall, inadequate and inaccessible road network, frequent floods, collapse of agro-industries such as problems with the sugar, rice, cotton and fish industries, lack of title deeds, poor water and sanitation systems, malaria, and waterborne diseases worsen the poverty situation in the County.

4.2 Agriculture, Livestock and Food Security

4.2.1 Agriculture

Agriculture is the mainstay of the population in the County, where mixed farming systems predominate; only a few farmers cultivate sugarcane and rice for commercial

purposes under mono-cropping systems. Approximately 34% of the land in the County is dedicated to subsistence crops, 34% to natural pastures, and 18% to commercial crop production; homesteads extend over 7% of the land. Small-scale production represents 90% of total agricultural production in the County; it accounts for 75% of the total agricultural output and 70% of the marketed agricultural produce. Some nucleus estates are established around sugarcane factories in Muhoroni and parts of Nyando Constituencies.

The County has 12 agro-ecological zones (Fig. 8). Agricultural potential varies by agro-ecological zone (AEZ).

- The coffee zone (UM1), which includes a tiny area near Maseno; The main coffee zone in Koru (UM2); annual temperatures 19.7-21.00 C, Average rainfall 1050-1400mm.
- The marginal coffee zone (UM3), which includes areas of Koru, also famous for finger millet, bean, sweet potato, sunflower (Kenya Fedha and Shaba), soybean (magoye), onion, cabbage, and other vegetables. Annual mean temperatures are 20.2- 20.80 C with average annual rainfall being relatively high at 1050-1400mm.
- The lower midland sugarcane zone in Chemilil (LM1); Annual mean temperatures 21-22.400 C, average rainfall 1450-1600mm.
- The marginal sugarcane zone (LM2), with excellent yield potential, covering areas like Muhoroni and Nyakach. The area is also home to other crops, including sunflower (Kenya Fedha and Shaba), soybean (magoye), chilli, sweet potato, and cucumber. Crops such as maize, sorghum, finger millet, bean, dolichos bean, cowpea, pigeon pea, groundnut, tomato, onion, pumpkin, kenaf, and roselle, also have a high potential for cultivation in the zone. Annual mean temperature ranges from 20.9-22.30 C, average rainfall 1400-1600mm.
- The lower midland cotton zone (LM3), which including areas such as Ahero, Miwani, and Rabuor and where rainfall (1100mm -1350mm) allows for two planting seasons, in August and December.

- The marginal cotton zone (LM4), where green gram, cowpea, chickpea, soybean, groundnut, pigeon pea, are cultivated. Annual mean temperatures 22^0C, Average rainfall 950-1100mm.

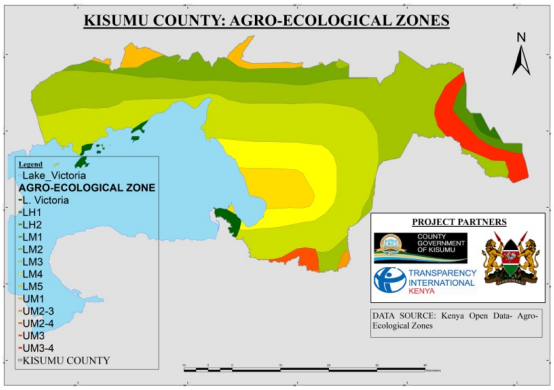


Figure 8 Agro-ecological zones of Kisumu County

There is a heavy reliance on maize as the main crop (Fig 9). As far as resilience is concerned, it is a disadvantage to heavily rely on one particular crop since it makes the community vulnerable if any of the shocks such as disease outbreak strikes.

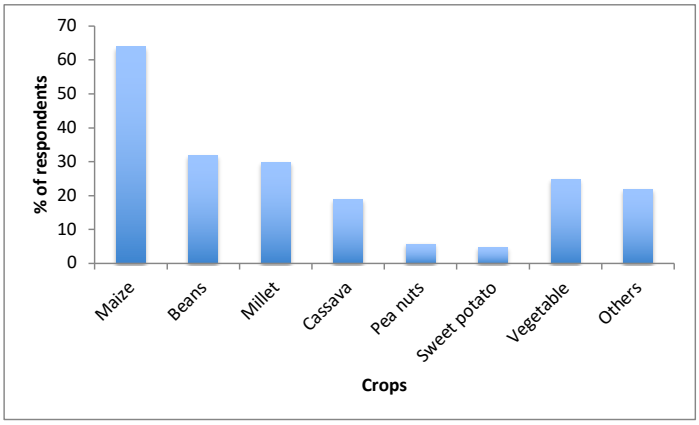


Figure 9 Food crops recorded.

The main cash crops are sugarcane, cotton, sunflower and coffee. Fertilizer use is low; approximately 17% of the farmers use organic manure, 5% basal fertilizer, and 6% top

dressing fertilizer. Some few farmers (2.5-2.6%) use field pesticides and herbicides for select annual crops (maize, beans, green grams, rice and sorghum). 4% of the farmers use storage pesticides to avoid post-harvest losses. As agriculture is mostly for subsistence, very few households hire additional labour. Almost all farmers resort to simple farm equipment, such as the ox plough and the hoe.

4.2.2. Food security

About 68% of the interviewed households did not produce enough food to cover for their household consumption for a whole year. Of the households facing a deficit, the households experienced food deficit for a varied period of time in a year with the majority of respondents (54%) indicating that they experience deficit for well over 4 months a year and only 46% experience shorter deficit periods of 3 months or less (Fig 10).

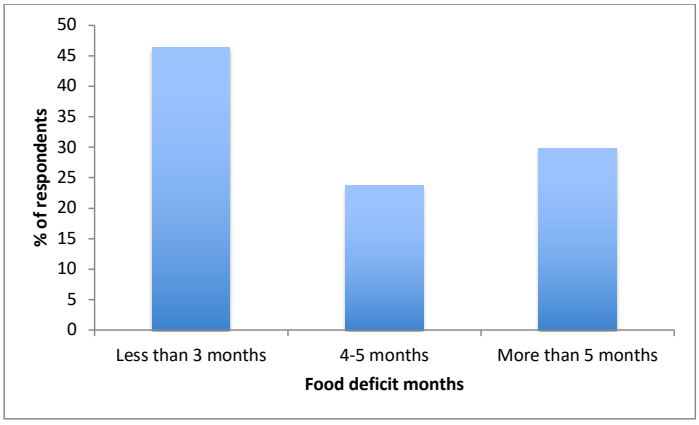


Figure 10 Food deficit months

Further analysis indicates that the location of the land is correlated with food deficiency. For example, in Fig. 11 it was observed that food deficiency is severe on the plains and lowlands compared to the uplands. According to the flood map (Fig 12), the plains and lowland are the flood-prone areas while Fig 13 show indicates that the plains and lowland experience low rainfall. These observations, therefore, shows that the biggest challenges to crop production are low soil moisture caused by drought and flood incidences.

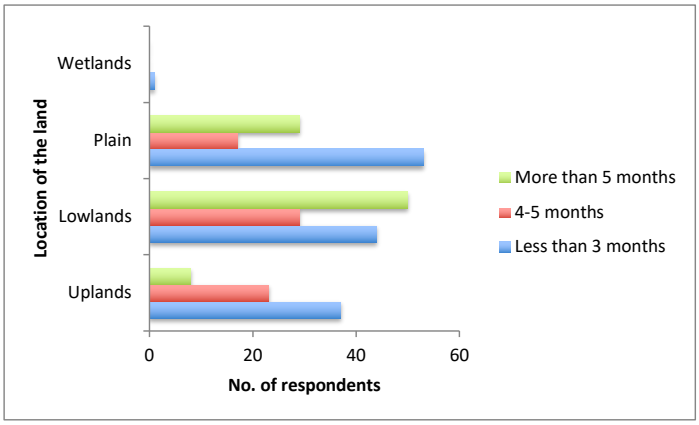
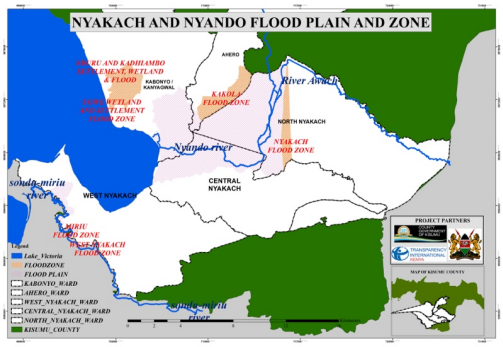


Figure 11 Location of the land versus food deficiency



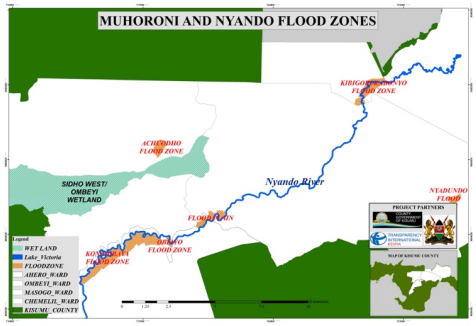


Figure 12 Flood zone areas

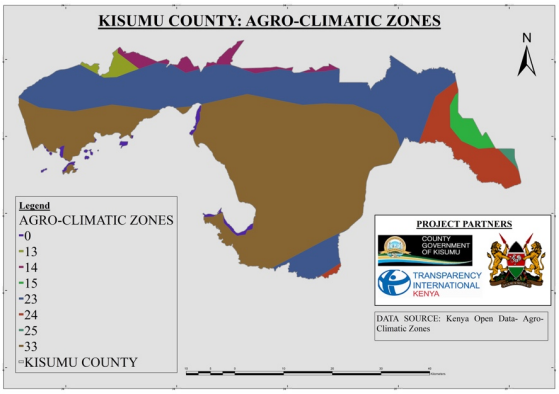


Figure 13 Agro-climatic characteristics of Kisumu County

4.2.3 Agricultural sector challenges and adaptation strategies

Flood, drought, rising temperature, pest and diseases were identified as the key challenges facing agriculture. This situation is exacerbated during the rainy season, when flooding affects the quality of water sources (especially in Nyando, Nyakach, and Muhoroni areas), causing damage to crops and properties and increasing the risk of waterborne diseases. The risk of flood, drought and rising temperature is expected to get worse with time due to the changing climate.

Land tenure and management is another challenge to agricultural production in the County. In the absence of clear title deeds and land delimitations, open grazing is a common practice, causing damages and even losses to crops due to animal interference. Moreover, population growth and cultural inheritance norms have led to further pressure on natural resources, leading to high land fragmentation that threatens the economic efficiency of agricultural production systems of most farmers.

Access to markets becomes especially tricky during the rainy season, due to the poor road infrastructure that gets affected by rains and floods. Moreover, for not being part of cooperatives and group structures, farmers lose their bargaining power to intermediaries and brokers, since they are unable to fetch reasonable prices for their products, to access credit, and pool resources for value addition. Despite the existence of a wide range of financial institutions (banks, insurance companies, and corporations), most of the credit facilities and insurance services available to farmers require them to

use their title deeds as collateral and incur high-interest rates, discouraging the use of such financial products and even farmers' engagement in agri-business.

Crop production is affected by a wide range of pests and diseases, e.g. stalk borers, smut, and aphids in sorghum. During the time of data collection, there was an outbreak of desert locust, which was observed in the Muhoroni and Koru areas.

When asked to suggest solutions to the perennial food insecurity situation in the County, the respondents give a wide range of solutions (Fig. 14). The suggested solutions include: Conservation of floodwater, irrigation of land during drought, provision of farm Input by government, reduction of post-harvest loses, control of pest and diseases and use of better and improved crop varieties. Diversification of livelihoods was also seen as one of the adaptation strategies. For example, in the plains where crop production was not doing well, more facilities resort to livestock production. Further, in response to some of the mentioned challenges, farmers in Kisumu County have come up with a wide range of on-farm adaptation measures to increase the resilience of their production systems and livelihoods to a changing, unpredictable climate. These strategies include soil management and conservation practices such as (staggered cropping, green manure, composting, ploughing back of the organic material). Others are promotion of drought-tolerant varieties of traditional crops (sorghum, cassava, green grams, sweet potatoes), intercropping with legumes (maize and sorghum in Stopamba, Nyakach), and also water conversation practices (rainwater harvesting and storage to enable use during the dry spell, water pans, and irrigation infrastructure). Smallholder irrigation schemes are currently extended over a total of 6,000 ha of land.

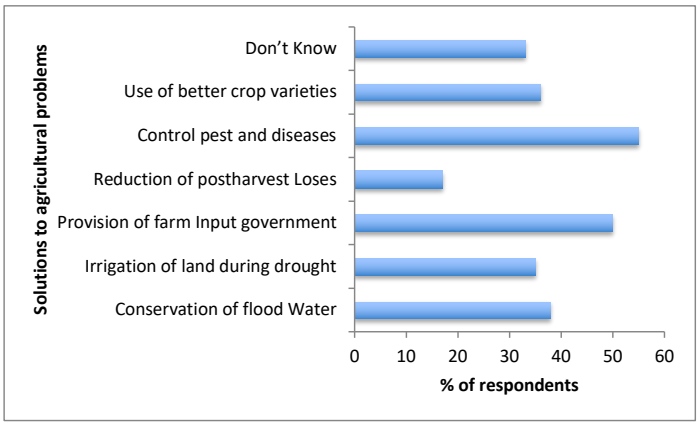


Figure 14 Suggested solutions to agricultural problems in the County.

4.2.4 Livestock production

The vast majority (62%) of the population in Kisumu County keep local poultry (Fig 15). Of those practising local poultry production, free-range (traditional) accounts for 85% of the production followed by semi-intensive (backyard) at 10% and only 5% practice commercial-intensive production systems. About 44% of the households keep local cattle while local sheep and goats accounted for 24% each.

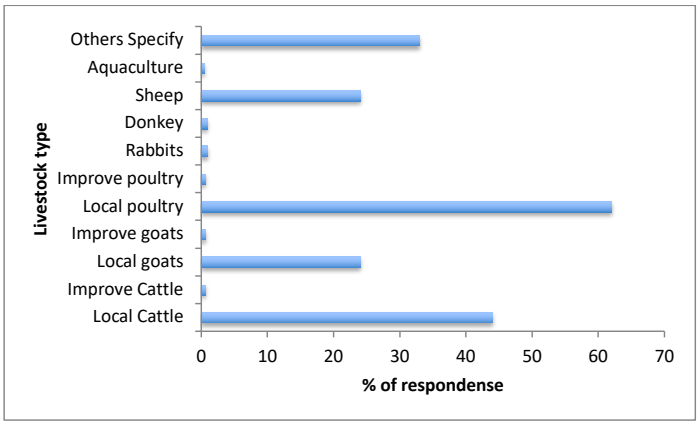


Figure 15 Type of livestock kept by respondents

Further comparison shows that the lowland areas of the County and plain areas have the highest number of households keeping livestock (Fig. 16). This is a welcome situation since lowlands were observed to experience the highest food insecurity, therefore keeping livestock becomes an adaptation strategy to caution against low crop production.

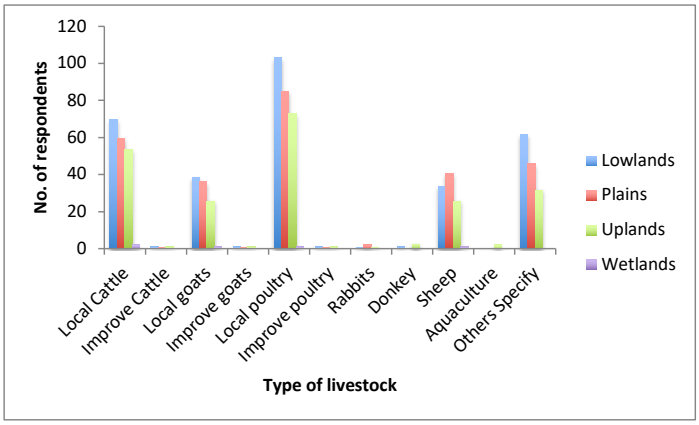


Figure 16 Livestock and land location

Livestock challenges and adaptation strategy

Livestock production is affected by a wide range of pests and diseases, e.g. stalk borers, smut, and aphids in sorghum, the East Coast Fever in cattle, Newcastle disease, Gumboro disease, Fowl typhoid, and Coccidiosis in the chicken value chain, tsetse flies, lung infections (pneumonia), worm load, and parasitic infections of worms in livestock. During the dry spells, there are cases of hand-foot-mouth diseases (HFMD) or even anthrax (in Nyakach Sub County in particular) which lead to severe livestock and economic losses. Other challenges identified include low productivity, water scarcity, access to livestock market, pasture especially during the drought season and inadequate animal health services.

For livestock farmers, common adaptation measures include: fodder conservation, zero grazing, drought-tolerant feeds (e.g. *Brachiaria*), pest control through crush pens, and vaccination. Climate-resilient breeds of sheep and goats have been introduced, and researchers now engage farmers in practical trainings on improved animal husbandry practices and on using simple information management tools to monitor the impacts of such practices. Creation of effective livestock diseases surveillance system is critical in addressing livestock diseases problem.

4.3 Water Resources

Kisumu County boasts abundant water resources due to its proximity to Lake Victoria. Rivers such as Nyando, Sondu-Miriu,Ombeyi, Awach, Nyaidho, Ang'wecha, Kibos, Magada, Mugru, Kisian, Saka, Auji, Kisat serve the County.

The study sought to determine the water access situation in the County. Access to clean water is a crucial pillar under the United Nation's Sustainable Development Goals (SDGs). Further exposure to climate change risks such as drought and floods affect water availability as well as quality. The respondents were asked to estimate the distance to the nearest water point. The study found that majority of the respondents (79%) could access water within a kilometre from their homes (Fig. 17). Nearly half of the households (47%) spend less than five minutes (one way) to fetch drinking water. Around 55% of the households have access to potable water, while only 8% have access to piped water. The study probed further to determine water access related problems the residents were facing. From the data water scarcity, especially during the dry season came at the top (Fig. 18).

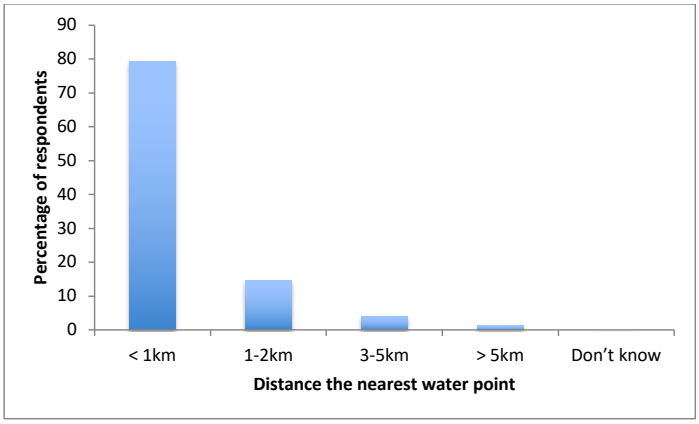


Fig. 17 Distance to the nearest water point

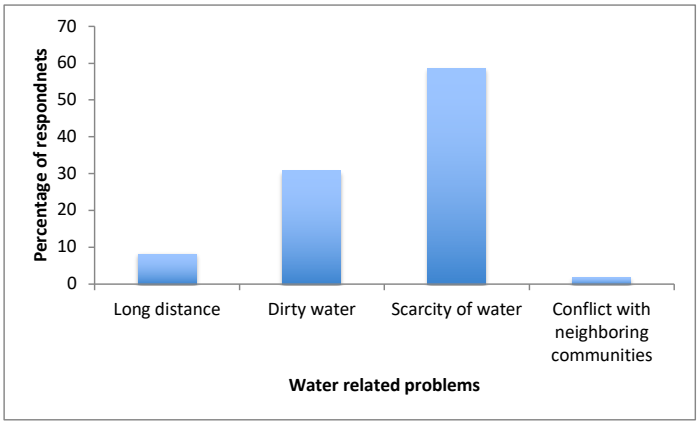


Figure 18 Water access related problems

The study went further to probe the leading cause of water scarcity in the County. Majority of the respondents (52%) indicated that the leading cause of water scarcity is a change in rainfall pattern over the years (Fig. 19). During the dry spell, some water sources dry up, compelling inhabitants (especially women and children) to travel even longer distances to fetch the water. This also drives conflicts among water users.

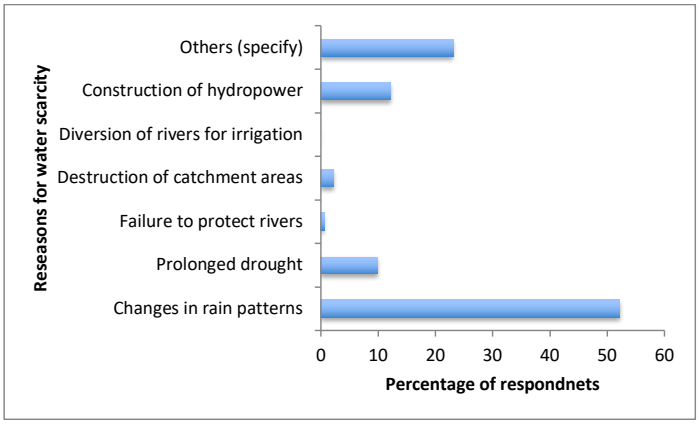


Figure 19 Causes of water scarcity

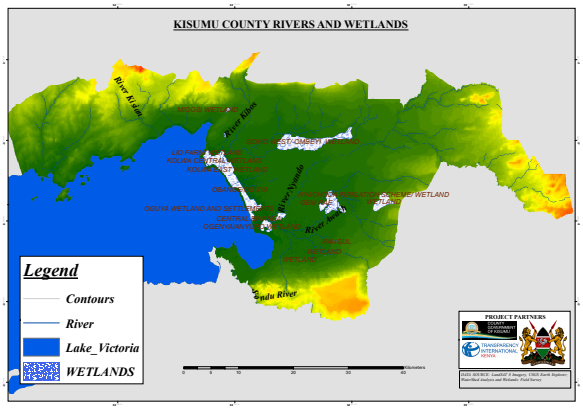


Figure 20 River and wetland systems in the County

Challenges and adaptation strategies

Degradation of upstream catchment (land area where water collects and subsequently flows into water bodies), mainly due to agricultural expansion associated with population growth, is already having negative impacts on the quality and quantity of water resources within the County.

Sand harvesting was identified as a significant challenge in the County. Sand harvesting exposes the river banks making the riverbeds to dry faster during the dry season (Fig 21).

Figure 21. Sand harvesting along River Nyando in Ahero ward

Access to safe water for human consumption and agriculture constitutes a significant challenge for the population in Kisumu County. As per the latest census, less than one per cent of the households had access to piped water in their dwellings. A large proportion of the population, 41.7% rely on springs wells and boreholes, while 37.6% fetch their water from the streams, 7.9% from ponds. In spite of many water sources, most are unsuitable for drinking, due to the high concentration of pollutants from effluent discharges from factories (especially along River Nyando and Kibos River), sediment loading from upstream farms, and siltation.

Further, several factors have contributed to the emerging water crisis in the County, whose result has led to poverty and poor health among the communities. These include factors such as the ever-continued growing population in urban areas, contamination of surface and groundwater, the frequent drought, water hyacinth invasion, destruction of forests and riparian areas, expansion of agricultural activities upstream, pollution of water bodies which have led to the uneven distribution of water resources.

Some of the pertinent issues related to the water resources are: Rivers breaking their banks causing severe flooding and destruction of properties such as crops, livestock and buildings and causing human displacement and sometimes death; spread of waterborne diseases during floods; Soil erosion leading to siltation of rivers and the lake. Other problems include pollution of water resources through waste and raw sewage disposal, chang'aa (local brew) brewing, car-washing and overexploitation of natural resources including papyrus reeds, sand harvesting, fish stocks and trees around the water resources.

Sand harvesting is also another major challenge in the County. Sand acts as a safe aquifer for water flowing below and through it. Sand harvesting results in destruction of underground aquifers and loss of safe water. Sand scooping adversely affects surface water quality and quantity and damages the aquatic ecosystem. Haulage of sand by heavy trucks causes environmental degradation by accelerating soil erosion and affecting soil stability.

With the changing rainfall pattern, rising temperature and prolonged drought, water problem is bound to become worse. The adaption strategy needed to address water problems must consider issues such as landscape restoration, integrated water resource

management, groundwater management including managed aquafers recharge systems.

4.4 Environmental conservation

Environment is one of the areas of concern in the County. The Kisumu County forest cover is estimated at less than 1% which include only one gazetted forest that is Koguta Forest and a few existing hilltops forests which have been proposed for gazettement such as Karateng A and B, Oruga, Nyatigo, Kajulu, Fort Tenan and Songoh. There are also several non-gazetted forests in the County such as Got Aila-Owaga, Ruke-Koru, Kanyagwal, Gem Rae, Orongo-Kolwa, Waware- North East Kano. The study sought to identify some of the critical environmental issues facing the County. In terms of tree planting, 83% of the respondents had planted trees in their farms. Kisumu Central had the highest number of respondents who have not planted trees (Fig. 22). This could be explained to be because a big population of Kisumu Central residents are living in rental houses, thus do not have any obligation to plant trees.

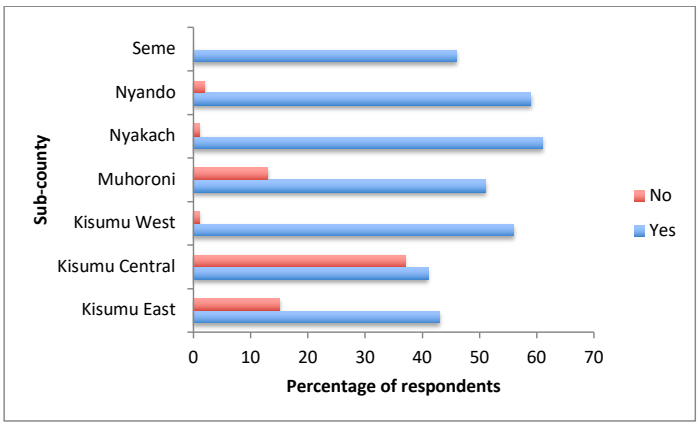


Figure 22 Tree planting

Further, majority of the respondents believed that the tree cover in their areas are diminishing (Fig. 23). This observation was further supported by the land cover map (Fig. 24), which shows a large extent of bear land and crop fields in the County. Diminishing tree cover could have a significant impact on the resilience of the community as well as the environment. Trees and forests are known to be the leading carbon sinks in the

world. Diminishing tree cover therefore means more carbon dioxide emission to the atmosphere. Further trees have essential roles in the ecosystem where they provide both products such as fuel, timber and poles and services such as soil fertility management, shade etc. It is, therefore, a big concern that tree cover is diminishing in the County.

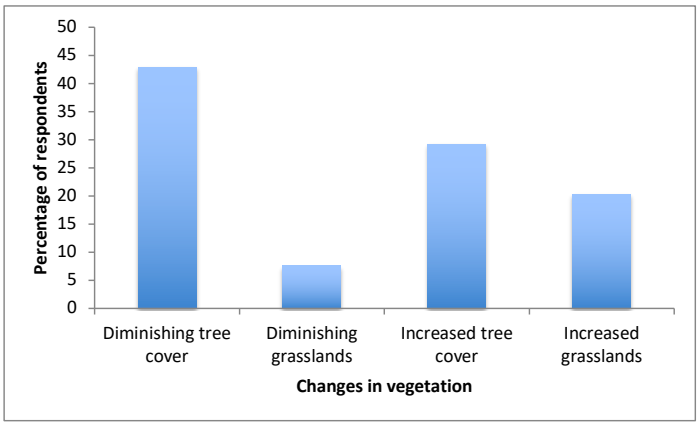


Figure 23 Change in vegetation

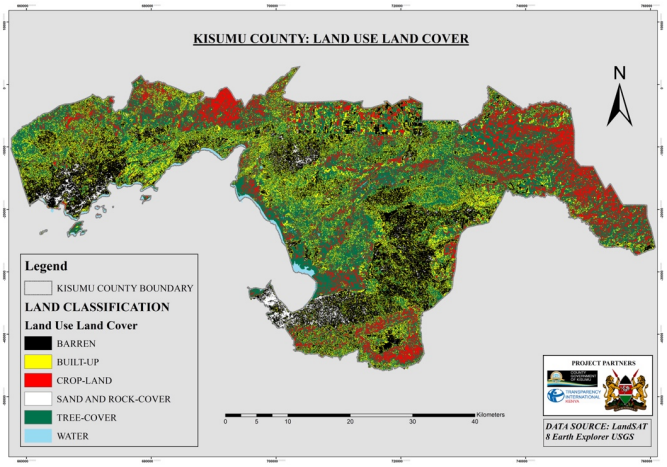


Figure 24 Land cover in Kisumu County

One key factor responsible for diminishing tree cover is felling of trees for woodfuel (firewood and charcoal). This is a common trend in North Seme where majority derive their daily livelihood from charcoal.

Figure 25 Charcoal making in process. This is a common trend in North Seme where majority derive their daily livelihood from charcoal

A critical environmental challenge observed is pollution. High population density in Kisumu and other primary and secondary towns contribute to pollution 'hot spots' caused by insufficiently managed human waste (both liquid and solid), urban runoff and effluent discharges from primary industries. While in the urban areas, informal settlements are the primary hotspot for pollution, in the rural areas where pit latrines are the primary type of sanitation, during the floods the human waste mix with flood water thus causing a high risk of water-borne diseases.

Figure 26. A section of Auji River passing through Manyatta B people complain that the river overflows during rainy seasons and has foul smell

Increasing nutrient inflow (nitrogen and phosphorous) to the Lake main from the farming activities upstream threatens the survival of deep-water fish species and ultimately, all life forms (Fig 27).

Figure 27. Algae and hyacinth growth are an indication of water with high content of nutrient from fertilizers

The main environmental issue affecting Winam Gulf is eutrophication of the shallow inlet. The principal sources of the nutrients are understood to be the sediment-laden rivers, untreated sewage and runoff from Kisumu and other towns, combined with increased absorption of nitrogen and phosphorous from the atmosphere which is

attributed to the changes in land use, notably the frequent burning of unwanted vegetation cover, dust and vehicle and industry emissions.

Eutrophication of the Lake waters has caused the proliferation of the invasive alien species water hyacinth (*Eicchornia crassipes*), more commonly known as the water hyacinth, which is endemic to South America. As with many other counties around Lake Victoria, water hyacinth has caused a significant disruption in fishing and Lake transport thus endangering the livelihood of many households in the County.

A combination of climate related risk factors such as rising temperature and frequent floods creates condusive environment for emergence of invasive species further threatening the health if the environment in the County.

4.5 Access to Healthcare

Access to healthcare is defined as "the timely use of health services to achieve the best possible outcomes, or the ease with which an individual can obtain needed medical services"[19]. Access to healthcare is a significant problem worldwide, as many poor or impoverished areas are far from healthcare facilities, are unable to pay for healthcare services, or do not have access to facilities with the necessary departments nearby. In the face of the changing climate, poor access to healthcare makes a population vulnerable to health-related risk caused by climate change.

The most often attended types of healthcare facility amongst all survey respondents were public dispensaries (40.2%) and public healthcare facilities (40.2%). Private healthcare facilities were used by 18.6% of respondents. No respondents reported the use of traditional healers, and 2.4% of people reported that they used other forms of healthcare services. In urban Kisumu County, most respondents (58.5%) go to public healthcare facilities when they are ill while in rural areas County, most respondents (78.1%) go to dispensaries. The three most common reasons respondents chose to go to the facility they usually go to are that the facility is near their home (32.6%), the facility offers quality service (20.0%), or that the facility has affordable services (47.4%).

[19] Lodenyo, M. M., Otsyula, B. K., Downing, R., Yakubu, K., Miima, M., & Ifeyinwa, O. (2016). Factors affecting the time of access of in-patient care at Webuye District Hospital, Kenya. African Journal Of Primary Health Care & Family Medicine, 8(1), e1-e9. doi:10.4102/phcfm.v8i1.898

Further, the study sought to determine the most prevalent diseases in the County. Our observation indicates malaria is by far the most prevalent disease mentioned by the respondents at (55%). HIV/AIDS and respiratory diseases followed this at 21% and 16%, respectively (Fig. 28).

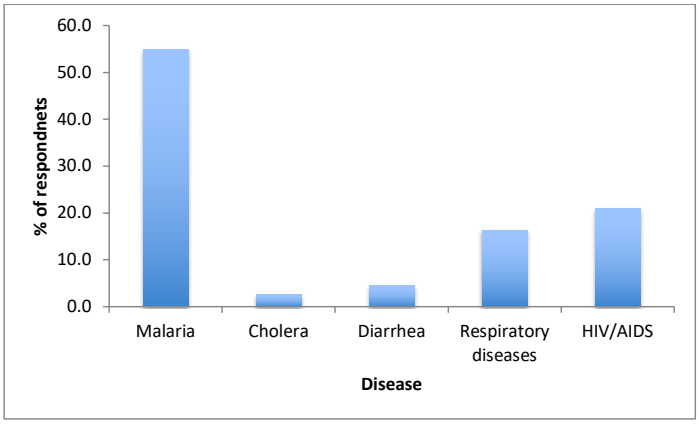


Figure 28 Disease prevalence in Kisumu County

When the respondents were asked to suggest a reason for disease prevalence, especially malaria, the majority (72%) responded that flooding was the main cause of the diseases (Fig 29). The respondents were unanimous that diseases are having a serious negative impact in the community. Three key areas were the main impacts caused by the diseases. These include high expenditure on hospital bill scored by 89% of the respondents, time spent on caring for the sick (67%) and less time spent on farm work (48%) (Fig. 30).

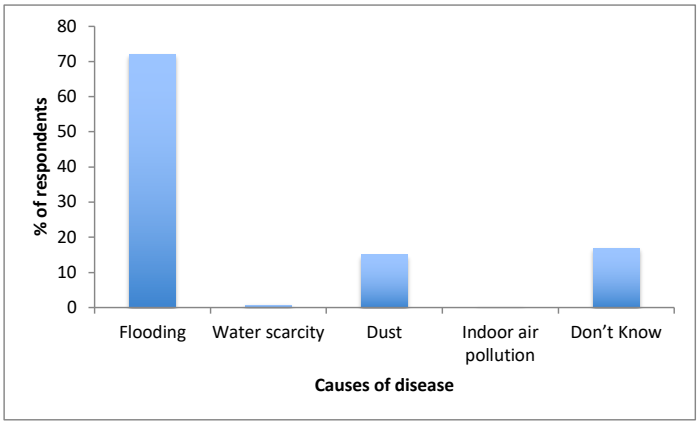


Figure 29 Cause of diseases

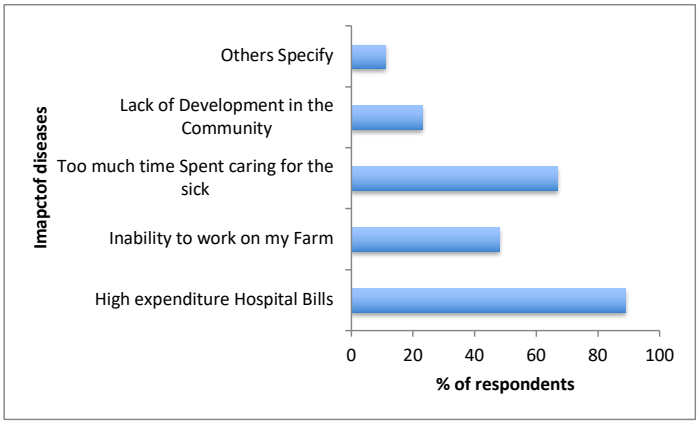


Figure 30 Impact of diseases

Most of the respondents indicated that they have access to health facilities within 0 - 2km distance (Fig. 31 and 32).

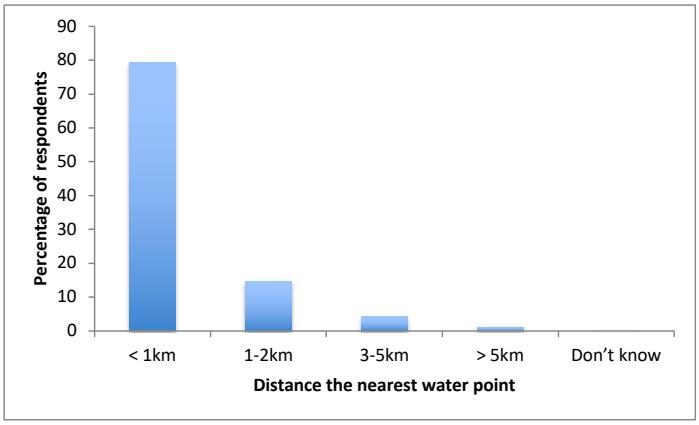


Fig. 31 Distance of health facilities

The combination of projected changes in climate-related exposures (e.g., temperature, precipitation, lake-level rise) reported elsewhere in this study will result in amplification of existing health risks and introduction of new risks with a high degree of spatial variability.

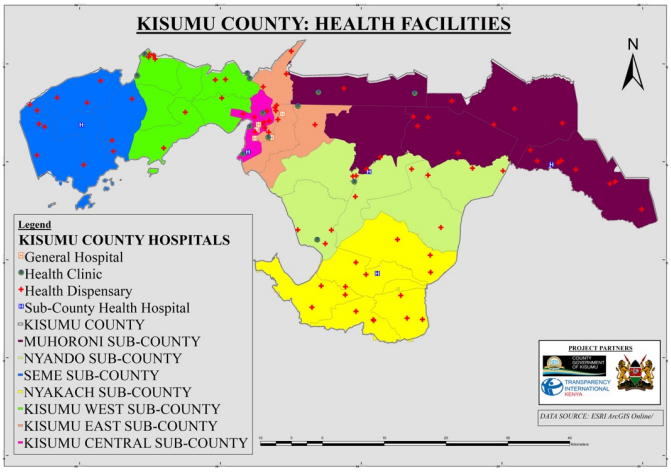


Figure 32 Health facilities in the County

Many adaptive measures have benefits beyond those associated with climate change. The rebuilding and maintaining of public health infrastructure are often viewed as the

“most important, cost-effective and urgently needed” adaptation strategy. This includes public health training, more effective surveillance and emergency response systems, and sustainable prevention and control programs.

Adaptation interventions which enhance a population's coping ability may protect against current climatic variability as well as against future climatic changes. Such "no-regrets" adaptations may be especially necessary for less developed countries with little current coping capacity.

> “…following heavy rainfall experienced in Kericho County, a section of the road near Ayweyo about four Kilometers to Ahero has been over-topped by floods, caused by River Nyalbiego,” KeNHA said in a statement.
> Consequently, traffic flow along the road section has temporarily been interrupted.
> “Motorists can use the following alternative routes. Ahero-Awasi-Katito road, Kapsoit-Sondu and Kericho-Kisii road,” KeNHA said.
> Star 26 March 2020 - 13:57

4.6 Infrastructure

Critical infrastructures are essential for the society and economy. In recent years, climate change has been identified as an urgent and growing threat to critical infrastructures, and many studies have been conducted to assess the vulnerability of critical infrastructures to climate change. Impacts of climate such as flooding, drought, heatwaves, wildfires, landslides, rising lake level etc. could have a severe impact on the infrastructural system causing changes in air quality, property damage, service disruptions, water quality, and habitat changes among others. Understanding these exposures are the sensitivity of the infrastructure in key in designing adaptation measures necessary to climate-proof the infrastructural system.

4.6.1 Road and transport

The study sought to determine the road network and road conditions in the County. Concerning the road network, data received shows that the majority of the households

(93%) are within a kilometre from a road (Fig. 33). Majority of the roads (53%) however are impassable during rainy seasons. Less than 15% of the road are of Bitumen standard. Given the frequency of floods in the County, road transport is seriously disrupted during the rainy season affecting access to markets, schools and health facilities.

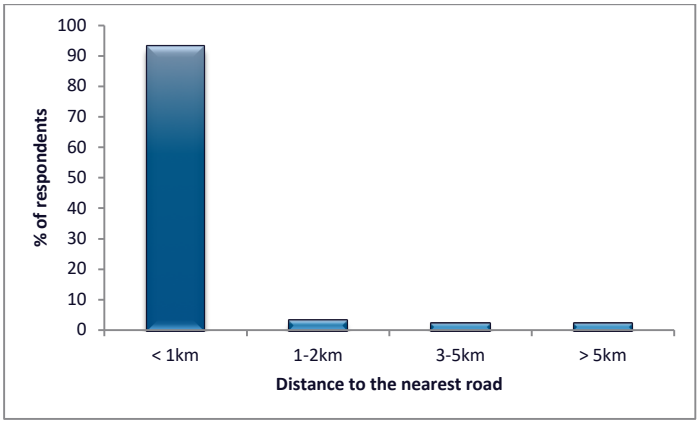


Figure 33 Access to road

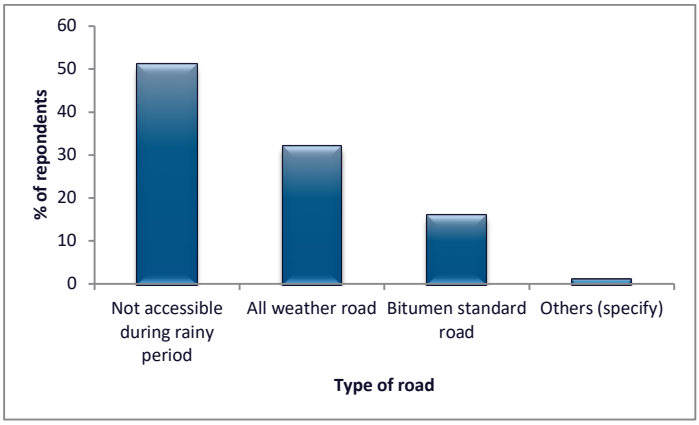


Figure 34 Type of road

Further examination of the roads' situation, showed that even though the road network seems good (within a kilometre) for the majority of the respondents, the type of the

road is a problem with data showing that over 50% of the roads are not accessible during rainy periods (Fig. 33 and Fig. 35).

According to road classification, our GIS analysis showed that 65% of the road network in the County are in class D, which is the lowest class (Fig. 36).

Figure 35 Flooded road

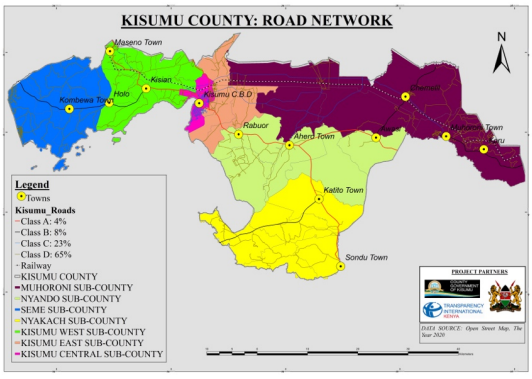


Figure 36 Road network and classification in Kisumu County

4.6.2 Sewage system

Waste management is one of the key environmental problems in Kisumu county. Kisumu, like many urban areas of developing countries, is grappling with increasing waste generation, an overflowing dumpsite and pollution from uncontrolled discarding of waste. Efforts abound to improve the situation, including relocating Kachok dumpsite. Despite the effort, poor sewage system, especially in the informal settlement areas such as Kondele, Obunga, Nyalenda, and Manyatta remains a big challenge. In some estates such as Kondele the team observed situations where residents were using freshwater mixed with sewage because of lack of alternative (Fig. 37).

Figure 37 Broken sewage system mixing with water

The changing rainfall patterns in the County coupled by and frequent flood the sewage system is increasing becoming a big threat to the health of the environment and humans alike.

4.6.3 Market access

The issue of market access is considered both as an issue of failed rail road network as well as inadequate market facilities in the County. Though about 62% of the respondents indicated that they are within a kilometre to the nearest market (Fig. 38) and 72% of the respondents indicated they could get all their necessities at their local market, over 80% reported that access to markets is disrupted during rainy seasons due to poor road networks.

Markets and trade are critical resilience factors. For example, there are numerous ways in which trade can help ensure food security in a changing climate. To transport food from one area to another, markets may be better able to facilitate the movement of food from areas of surplus to areas of deficit. Both of these factors are likely to reduce food availability challenges created by climate change[20].

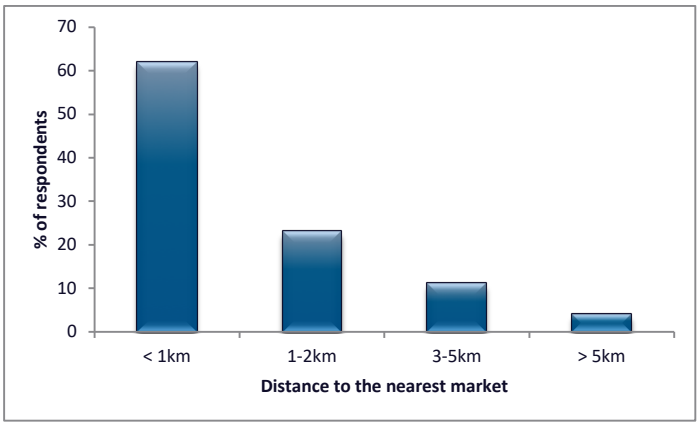


Figure 38. Distance to the nearest market

4.6.4 Education facilities

Majority of the pupils in the County can access educational facilities within 0 – 2km distance of their residence with no significant difference between the various sub-counties. However, the respondents indicated that poor roads and floods are the main challenges facing access to education. Nyando, Nyakach and parts of Muhoroni Sub-counties were the worst affected area the flood problem (Fig. 39).

[20] http://www.foodsecurityportal.org/what-role-do-markets-and-trade-play-climate-change-adaptation

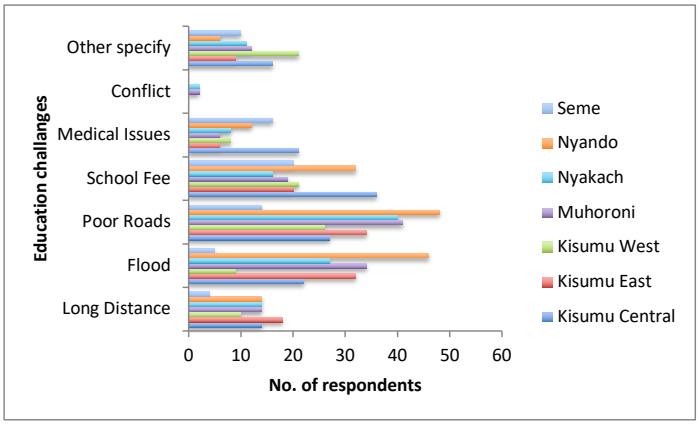


Figure 39 Problems facing access to education

During the current study, which took place during rains, severe cases of flooded schools, and halted learning were observed (Fig. 40). Further, floods have severe impacts on other spheres of life, such as affecting the transport, diseases outbreak and displacement of communities.

Figure 40. Submerged school in Nyando, Kisumu

4.6.5 Access to Technology

On ICT infrastructure, 88% of the respondents have a mobile phone for communication. However, of those with a mobile phone, only 25% are smartphones. Majority of the respondents have access to radio and TV (Fig. 41). Access to ICT is vital in climate change adaptation as it provides a channel for passing adaptation message to the vulnerable population.

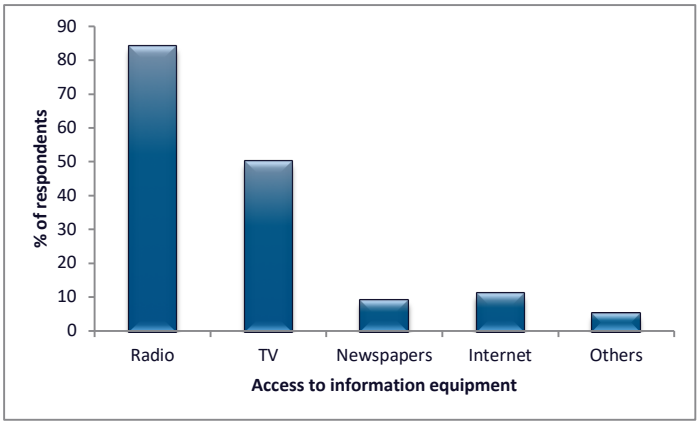


Figure 41 Access to information equipment

Further, the study sought to determine from what source the respondents receive climate-related information (early warning). From the responses received, radio and TV are the primary source of climate-related information (Fig 42). However, the study revealed other sources of information that should not be ignored such as social gatherings and markets since they serve a particular segment of the society, especially those who may not have access to the mainstream sources of information.

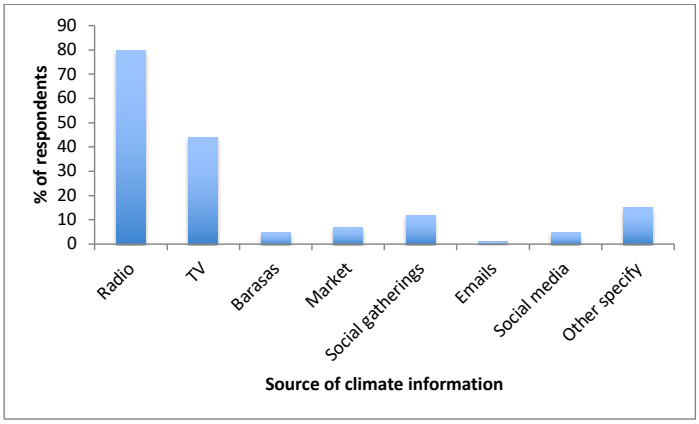


Figure 42 Source of climate-related information

4.6.6 Energy access

Clean energy provides a golden thread to deliver on the promise of Agenda 2030 Sustainable Development Goals (SDGs) and the Paris Agreement. It can unlock sustainable economic growth, improve human health and well-being and enable women and children to lead more productive lives[21]. Beyond direct economic and social benefits, clean energy access will raise human security and build resilience in states and communities to help limit the risk of large-scale migration across the African continent[22].

The study attempted to establish the status of energy in the County and household energy access. Kisumu County is home to two grid-connected hydropower plants, Sondu Miriu with an installed capacity of 60 MW, and Sang'oro with an installed capacity of 21 MW. There is also 30 MW of diesel emergency power that is provided by Aggreko, which is an Independent Power Producer (IPP). The data obtained shows that firewood and charcoal are the most dominant fuel used for cooking accounting for about 74% and 67% of the respondents, respectively (Fig. 43). It is worth noting that there were pockets of people using briquette and biogas, which are some of the cleaner cooking solutions compared to firewood and charcoal, which are the traditional biomass systems.

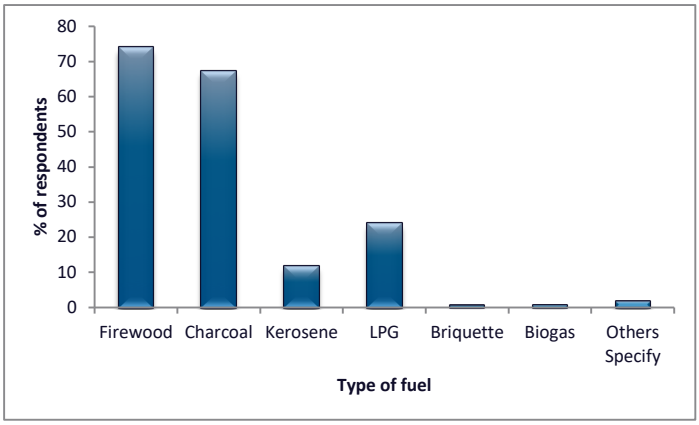


Figure 43 Type of fuel used for cooking in the County

[21] UN (2018). Sustainable Energy 'Golden Thread' Linking 2030 Agenda with Pledge to Leave No One Behind, Especially Rural Women, Deputy Secretary-General Tells Side Event, Press Release, 16 July.
[22] Rigaud, K. K., A. de Sherbinin, et al. (2018). Groundswell: Preparing for Internal Climate Migration. World Bank, Washington DC.

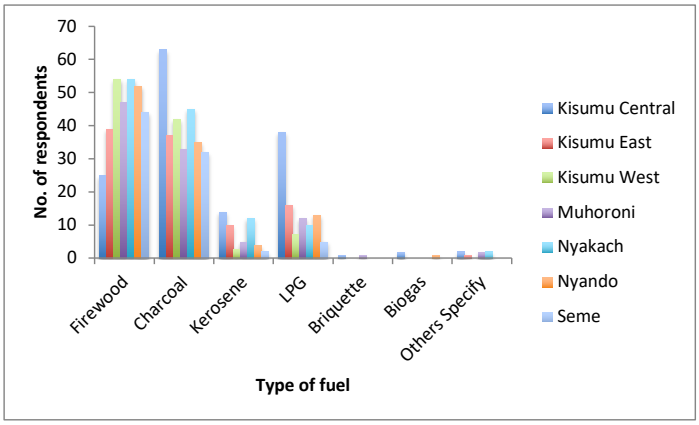


Figure 44 Type of fuel used for cooking by sub-county

Comparison between the sub-counties shows that LPG is the leading fuel in Kisumu Central, while firewood and charcoal were the leading fuel in the other sub-counties. To put this into perspective, Kisumu Central largely composed of Kisumu City and as expected in the cities, people tend to use liquefied petroleum gas (LPG) (Fig. 44).

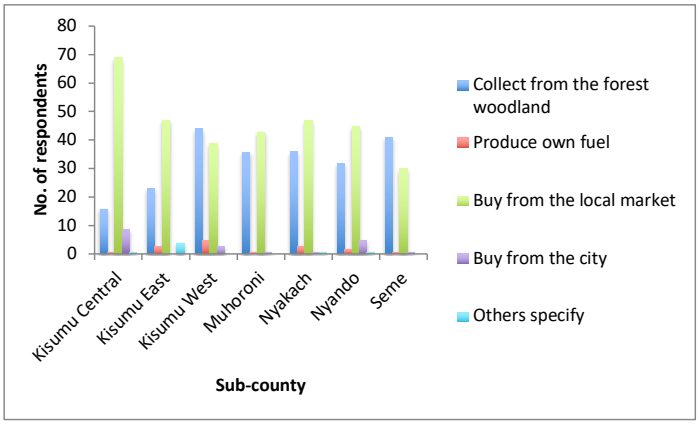


Figure 45 Source of fuel

From the data collected, it was clear that in all the sub-counties, majority of the respondents are buying fuel. The highest numbers of households buying fuel were

observed in Kisumu Central. Data collected further indicated that 75% of the population is facing fuel scarcity.

The study also sought to understand the type of cookstoves used by the households. From the response received, traditional three-stone cook stove remains the dominant type of cookstove in the County, as indicated by 73% of the respondents (Fig 45). This was followed by a metallic cookstoves (33%). Suffice to mention that these two are in the lowest tier of cookstoves standards according to the classification of cookstoves (GCCA, 2013).

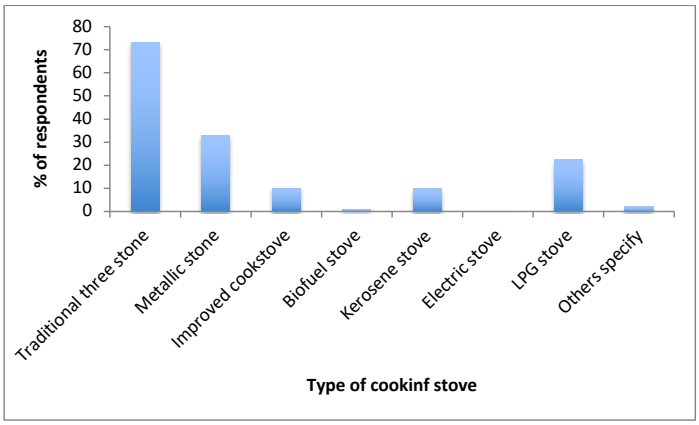


Figure 46 Type of cookstoves used by households

Comparison was made on the type of cookstoves used by household by sub-county. From the data collected, it was by far clear that except for Kisumu Central where the use of LPG was dominant, most households are using the three-stone cookstove (Fig. 46).

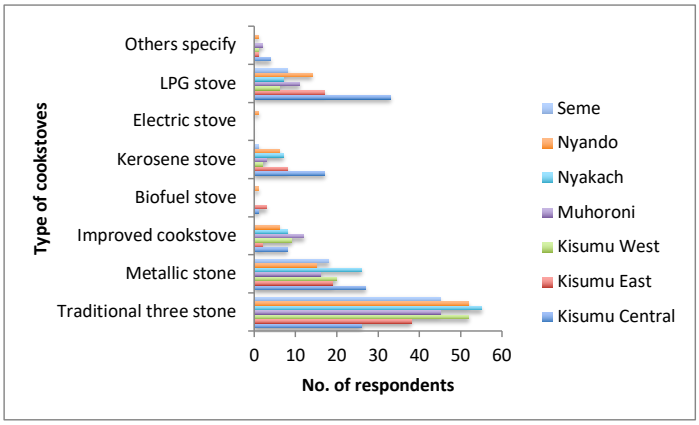


Figure 47 Type of cookstoves by sub-county

The residents seemed to understand the impact of using traditional biomass. Figure 47 shows the response reached when households were asked about the impact of using traditional biomass. From the data, health-related problems scored the highest, followed by time wasted in collecting firewood. The other problem mentioned was deforestation. These are critical problems with Kenya estimated to have upto 15,000 deaths per year due to indoor air pollution-related respiratory diseases mainly caused by the use of traditional biomass (WHO, 2010).

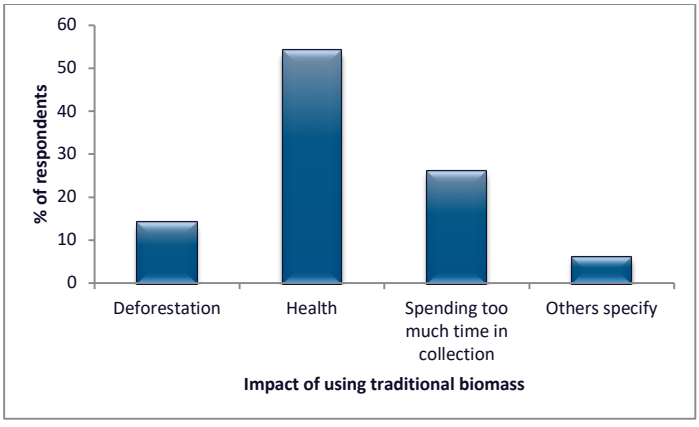


Figure 48 Impacts of using traditional biomass

Asked to suggest a solution to household energy problem, majority of the respondents (37% and 28%) were of the opinion that they would change to cleaner fuel type or more efficient cookstoves, respectively. It is also worth noting that planting of woodlot was also proposed as a solution (Fig. 48). While planting of trees will not solve the problem of use of traditional biomass system, it could ensure environmental sustainability since fuelwood will be coming from sustainable sources. This could be considered a win-win situation since the trees would provide fuel while also improving tree cover, which has been pointed out as one of the leading environmental problems in the County.

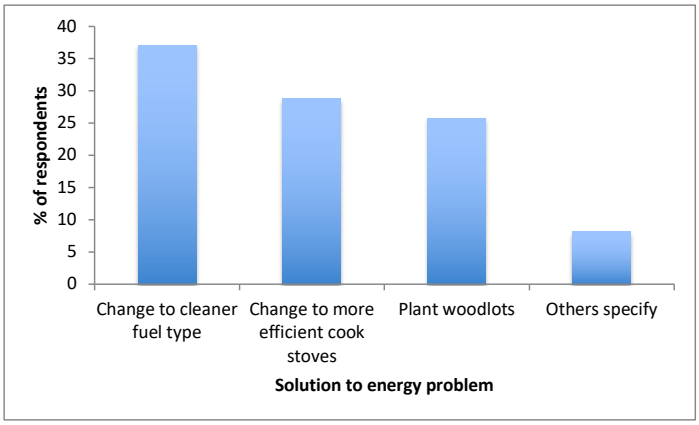


Figure 49. Solution to energy problems

While energy is mainly a mitigation issue, there are inbuilt adaptation outcomes. For example, use of traditional biomass is known to be a major cause of indoor air pollution related diseases such as respiratory diseases. It is estimated that exposure to smoke from such households results in 4 million deaths annually globally due indoor air pollution (IAP) (or household air pollution (HAP)) related diseases, with millions more suffering from acute and chronic respiratory diseases, heart diseases, blindness and burns[23]. Kenya records an average of 15,000 mortalities annually due to IAP related diseases[24].

[23] Lambe, F., Jürisoo, M., Lee, C. et al. 2015. Can carbon finance transform household energy markets? A review of cookstove projects and programs in Kenya, Energy Research & Social Science, 5, 55–66. https://doi.org/10.1016/j.erss.2014.12.012.

[24] World Health Organization (WHO). 2010. Guidelines for Indoor Air Quality— selected Pollutants. WHO Guidelines, Vol. 9, WHO Regional Office for Europe, Copenhagen. https://doi.org/10.1186/2041-1480-2-S2-I1.

4.6.7 Housing and settlement

The study sought to determine the type of houses respondents are living in. Type of house is a crucial vulnerability factor, especially in areas prone to flooding. In terms of housing, there were very few respondents (less than 1%) with mud-walled grass-thatched houses (Fig 50). This category of housing are the most vulnerable to flood. The next category in terms of vulnerability is mud-walled iron sheet roofing, which carried the majority of the respondents (42.3%). Only 20.3% of the respondents had the least vulnerable, stone walled (permanent house).

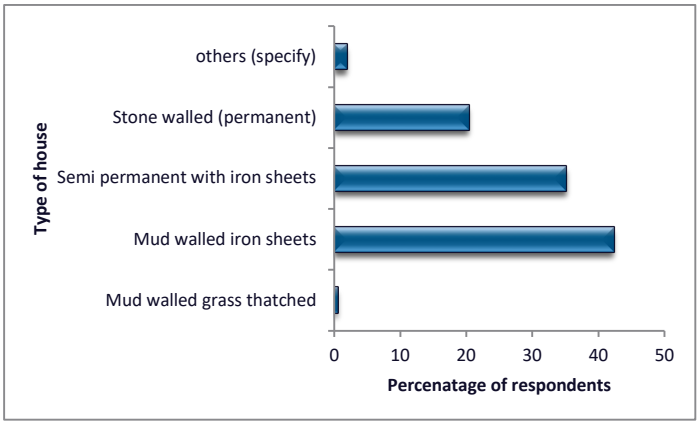


Figure 50 Type of house

Further analysis shows that there is a correlation between household type and level of education at a 95% significance level (p-value = $7.543e^{-05}$). In households where members have higher education levels, house types are more modern in nature and less vulnerable to climate risks such as flood.

Figure 51 Mud-walled grass-thatched house and mud-walled iron-roofed house

Future scenarios - Climate change may cause the amount of rainfall in the Lake Victoria basin to fluctuate, which will have a direct impact on the water levels in the Lake. Earlier research predicted that the level of the Lake would fall by the 2030s, then rise again by the 2080s. Our study, however, came up with a different picture. Both observation and talk with the local people confirmed that Lake has been expanding its shoreline to the riparian zone for the last almost three years with the current year 2020 being the furthest it has expanded inland. This phenomenon has had a severe impact on the surrounding communities making rising lake level one of the leading climate chocks the County is experiencing.

Figure 52. Lake Victoria shoreline expanding inland and threatening settlement and other development

4.7 Overall vulnerability

4.7.1 Climate perception of the respondents

Most farmers in Kisumu County already face the effects of climate change and variability. Households generally reported poor distribution and higher variability and unpredictability of rains, affecting the plants' growing season, as well as increased cases of floods in Miwani and Ombei, the Nyando basin, the Kano plains, the lower Nyakach areas, and Kisumu East. "Being a farmer in this area (Ombei) for over 30 years, I have experienced how climate change and variability has affected farm production. In the past, we could predict the onset of rains accurately, but currently, it is impossible to know when the rains are expected. Further, we used to have two robust seasons every year now we have one and have resulted in planting drought-tolerant crops such as sorghum." Higher temperatures and heat stress, prolonged dry spell in areas of Nyakach, Seme, and Nyando, and stronger winds, have also become more regular, in their opinion. Soil degradation, drying of wells and rivers, and reduction in water volumes are some of the many environmental challenges that regularly hit already vulnerable farmers. All these combined have brought about new weeds, pests and diseases, have reduced sizes of pastures and spawned conflicts over land resources, caused crop failures, and increased food insecurity and even costs of living in the area.

These risks have affected agricultural production causing food insecurity and growing poverty, low per capita water availability and host of soci-economic impacts such as disease outbreaks and epidemics, and access to education facilities, among others. Current climate change is extremely rapid, which places additional stress both on the capacity of ecosystems to adapt and on the lifespan of infrastructure. In health a combination of projected changes in climate-related exposures (e.g., temperature, precipitation, lake-level rising) reported in this study will result in amplification of existing health risks and introduction of new risks with a high degree of spatial variability. Agriculture were observed to be the most vulnerable sectors which is mainly due to drought, raising temperature, flood, and emergence of numerous diseases and pests. Climate change is, therefore, projected to compromise agricultural production, especially in smallholder systems with little adaptive capacity, as currently prevalent in many parts of county.

The increasing changes in climate will pose challenges for the County's development aspirations. With continued increases in greenhouse gas emissions, the atmosphere and oceans will warm, rainfall patterns will change, the frequency of drought and flood incidences will increase, all these changes serve to increase the challenges to Kisumu's development. The loss of environmental assets due to climate change will affect many people and the economy with devastating effects on people, their culture, and their livelihoods.

4.7.2 Overall impact

Development goals of Kisumu County are primarily at risk from the impacts of climate change. These impacts are already becoming a severe burden to the County's economy and its people. The risks of changing climate in Kisumu County is already being felt in the extended and frequent drought, frequent flood and raising temperature. These risks have affected agricultural production causing food insecurity and growing poverty, low per capita water availability and host of socio-economic impacts such as disease outbreaks and epidemics, and access to education facilities, among others.

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Based on the overall observation in different sectors

Overall vulnerability by sector

Sector	Flood	Drought	Rising Temp	Changing rainfall patterns	Diseases and pests	Lake level rising	Invasive species	Overall vulnerability
Agriculture &Livestock	x	x	x	x	x	x	x	
Water	x	x		x	x	x	x	
Environment	x	x	x	x	x	x	x	
Health	x		x		x	x		
Roads and transport	x			x		x	x	
Sewage	x			x	x	x		
Market	x				x			
Education	x				x	x		
Technology	x							
Energy	x	x			x			
Housing	x		x		x	x		

Low (1-2 factors) Medium (3-4 factors) High (5-7) factors)

Overall vulnerability by sub-count

The study has demonstrated that all sub-counties are vulnerable to climate change. The key vulnerability factors (**exposures**) include drought, rising temperature, climate related diseases and pest, lake level rising and invasive species. The key factors that makes the country vulnerable to the exposure (**sensitivity**) factors include high level of poverty, settlement patterns, poor land management practices, use of poor-quality crop and animal breads, growing population, among others. Further the study has demonstrated evidence of low **adaptive capacity** in the County. The combination of the three factors has caused high vulnerability in the County.

Sub-county	Flood	Drought	Rising Temp	Climate-related Diseases and pests	Lake level rising	Invasive species	Overall vulnerability
Kisumu Central	x		x	x	x	x	
Kisumu East	x	x	x	x	x	x	
Kisumu West	x	x	x	x			
Seme		x	x	x	x	x	
Muhoroni	x	x	x	x			
Nyando	x	x	x	x	x	x	
Nyakach	x	x	x	x	x	x	

Key

Low (1-2 factors)	Medium (3-4 factors)	High (5-6 factors)

5. THE OPTIONS: MAJOR INTERVENTION AREAS TO ADAPT TO CLIMATE CHANGE

This section presents the key recommendations that came out of this study. The proposed interventions are considered necessary to achieve the County's climate change policy objectives and will have benefits that persist far beyond the decade of initial investment; they are not based on a least-cost approach. All interventions included in this report have benefits linked to climate and disaster risks, but also broader benefits in terms of development outcomes, poverty reduction, or access to infrastructure services.

5.1 Housing and Settlement in Safe Areas

Current settlement trends in the County lead to unplanned development, including in areas with significant and increased levels of natural risks such as flood-prone areas, wetlands and Lakeshores. To address the problem, the study recommends the following measures:

i. Develop a comprehensive digitalized spatial plan for the whole County to control and prevent development in unsafe areas and reduce vulnerability of settlement areas.
ii. Partner with the private sector to provide safe and affordable housing solutions in the County
iii. Work with the private sector to strengthen the quality and availability of affordable local construction and building materials industry.
iv. Assess the efficiency of the rental market and work to ensure that it meets the needs of the extremely poor.
v. Upgrade informal settlements for current and future risks by adopting a passive planning approach for in situ upgrading of the settlements

5.3 Strengthened Infrastructure to Meet the Needs of the County Economy and Population

Infrastructure specifically designed to reduce vulnerability to climate variability (e.g., flood control structures and decentralized energy systems) and general public health

infrastructure (e.g., sanitation facilities, wastewater treatment systems, laboratory buildings) enhance adaptive capacity. However, infrastructure (mainly if immovable) can be adversely affected by climate, especially extreme events such as floods. Based on the findings, the study recommends:

i. The County to investments in climate proofed flood risk management such as dykes, riverbank draining and drenching, etc.;
ii. Desilting of rivers and streams;
iii. Drilling of more boreholes;
iv. Digging of canals to direct water to the lake;
v. Extending piped water provision to households;
vi. Shoreline protection measures through legislative means and protection walls where necessary;
vii. Invest in resilient road network to critical installations and services such as schools, health facilities, market etc.;
viii. Improve water transport by addressing safety issues, impact of water hyacinth and necessary by-laws;
ix. Build/strengthen energy systems for climate resilience and enhance access to clean energy by the poor;
x. Improve water and sanitation services primarily in the informal settlement, peri-urban and rural areas;
xi. Improve health infrastructure by reducing the average distance to the health facility, number of health service providers and relevant supplies. Community health volunteers play a critical role in providing health services in rural areas;
xii. Completion of the health facilities construction such as Ugwe, Kanyagila, Komwaga, Ogenya and Reru.
xiii. Improve access to technology such as smart mobile phones to support early warning and climate information services, agriculture, water resources and health-care systems;
xiv. Invest in education infrastructure (Classrooms and toilets);
xv. Construction of footpaths along rivers that connect wards; and,
xvi. Introduction of lunch programmes for primary schools especially during drought.

5.4 Support Climate Smart Agriculture and Fisheries Development to Drive Sustainable Economic Development

If farmers and fishers are enabled to adapt to weather threats, and climate extremes in the short and medium-term, future generations will be better placed to adapt to climate change, whatever specific form it takes. Measures that improve productivity while also building resilience to future climate change are generally referred to as “no-regret" measures—that is, actions that make sense even in the absence of climate change. The study recommendations:

i. Promote/Provide farmers with climate-resilient crop varieties and animal breeds;
ii. Build the capacity of farmers to adopt sustainable soil management;
iii. Support renewable energy-based efficient irrigation technologies;
iv. Promote/support improved climate-resilient fishery technology;
v. Develop and implement agriculture insurance programs to manage the financial cost of disasters to farmers and government;
vi. Provision of farm inputs by the county Government;
vii. Employment of Agricultural extension officers to advise farmers on correct farming methods;
viii. Construction and provision of water reservoirs for irrigation;
ix. Provision of market for farm produces;
x. Cold and storage facility for fish
xi. Promote integrated pest management; and,
xii. Promote sustainable agricultural systems such as agro-forestry.
xiii. Domesticate and implement the Kenya Climate Smart Agriculture Strategy

5.5 Environmental Protection

The combined effect of growing population and impacts of climate change has a significant pressure on the environment resulting in environmental degradation causing serious challenges such poor land use planning, lack of proper liquid and solid waste management; unregulated point and non-point source pollution; dropping water levels; Increase in silt loads entering the lake; catchment degradation (Land and forests); lack of protection of wetlands; and loss of biodiversity and ecosystem services.

Kisumu's economy is resource-based relying heavily on farming, fisheries as well as for related livelihoods. Disruption of this system, therefore, has led to severe problems. For example, land degradation results in low food production and increased poverty. Strengthening and enforcement of environmental governance is, therefore, a key to long-term resilience building. The study recommends:

Some of the needed actions include:

i. To build on the existing Kisumu Environment Policy, the County needs to develop and implement strong environmental legislation, which is essential to minimize further degradation of the ecosystems and ensure their continued protection;
ii. Develop and implement a clear action plan to preserve soil and soil fertility, including through training and capacity building of communities, in order to maintain agriculture production for food security and livelihoods;
iii. Investments in community-led protection of forest, wetland, lakeshore, and riverbank areas;
iv. Develop and implement a comprehensive waste management policy and strategy to reduce pressure on the environment and ecosystems;
v. Conserve protected areas to withstand increasing pressures and effects of changing climate;
vi. Invest in eco-tourism.

5.6 Build Socioeconomic Resilience to Take Care of the Poor and Keep Economic Growth Inclusive

For vulnerable and low-resilience populations, it is critical to provide the tools and support they need to manage and recover from the natural shocks that cannot be avoided. Indeed, appropriate land-use planning and building norms, as well as better infrastructure, can help minimize the risk that natural hazards like heavy precipitation will translate into natural disasters, but they cannot prevent all shocks. Some shocks are unavoidable, especially in highly exposed areas. Moreover, the County will continue to have a share of its population at high risk and with limited capacity to cope with and recover from shocks. This population will remain dependent on government and community support after disasters.

Similarly, people stuck in low-income activity will need support to benefit from economic growth. Growing sectors can provide new and higher-productivity jobs, but vulnerable

populations may struggle to capture those opportunities and risk being locked into low-productivity or decreasing productivity jobs and activities. For those, dedicated policies are needed to improve their wellbeing, help them capture opportunities and accumulate assets, and ensure that their children do not inherit poverty and vulnerability from their parents.

The study recommends thus:

v. Establish an effective early warning system and preparedness to save lives and protect assets;
vi. Establish a social protection mechanism including Insurance-based solutions to make the population better able to cope with shocks;
vii. Improve the health care system to improve resilience and build capacity to prepare for climate change-induced health emergencies;
viii. Ensure Equity by providing targeted gender interventions and specific measures to protect vulnerable populations in all sectors, including prevention of gender-based violence (GBV).
ix. Ensure a conducive policy environment that will facilitate creation of green jobs

5.7 Nurture Evidenced-based Decision Making, Private Sector Participation and Capacity Building

Designing a resilience strategy for the County would require constant data supply, and the use of these data for evidence-based decision-making, in particular regarding new investments and maintenance prioritization. The study recommends:

iv. Provide a framework for continuous data collection and analytical work;
v. Create a framework for climate financing and private sector participation; and,
vi. Build capacity of stakeholders and enhance community awareness on climate change risks and adaptation.
vii. Establish a reporting framework for climate action by all stakeholders in the County

6. CONCLUSION

This study has demonstrated that the changing climate is creating serious challenges for the County's development aspirations. The frequency of flood incidences, the prolonged

drought, rising temperature, the rising levels of lakes and rivers are increasingly impacting of food security, growing poverty levels, human and livestock health challenges. With continued increases in greenhouse gas emissions, the atmosphere and oceans will warm, rainfall patterns will change, the frequency of drought and flood incidences will increase, all these changes serve to increase the challenges to Kisumu's development. The loss of environmental assets due to climate change will affect many people and the economy with devastating effects on people, their culture, and their livelihoods.

Kisumu County needs to urgently invest in building resilient systems to address the impact of climate change. This will require policy interventions and financial investment to achieve—the participation of all stakeholders is essential, including the government, civil society, academia and the private sector as well as community buy-in. Such intervention must be superseded by the right policies, political good will and strategic partnership with the civil society, private sector and other development partners. The interventions for climate change impacts will be multifaceted in order to provide sustainable development direction. These will include development and implementation of the County Climate Change policy, County climate change Act and the County Climate Change Action Plan. Besides, the climate change policies must be harmonized with County Disaster management policy, Mainstreaming Climate change in the County Integrated Development Plan and other related sectoral polices such as agriculture, livestock, water, health etc.

The County should also have Climate Change Adaptation Plan for ten years that will be monitored and tracked in Implementation through the County Climate change Action Plan. The implementation and actualization of the Sustanable Energy and Climate Change Action Program (SEACAP) supported by COMSA and technically driven by Expertise France is an added advantage to the City as well as County Government of Kisumu since it will enhance professional and technical direction. The need to provide strategic direction from the County Government through the Climate Change Directorate will be critical.

Finally, the Climate Change Vulnerability Assessment Report is a critical document in the preparation of a collectively driven process in the development of a County Climate Change Action Plan for 2020-2022.

Appendix 1: Climate vulnerability at ward level

Sub-county	Ward	Vulnerability	Impact	Adaptation Strategy
Kisumu East	Kajulu	Unpredictable rainfall patterns and intensity; Rising temperature; Flood Drought	Soil erosion; Crops failure; Water quality and quantity; Destruction of property; Drying of springs; Lowering of water table level; Water scarcity Waterborne diseases	Diversification of livelihood; Use of fertilizers. Drilling of boreholes; Water treatment; Construction of gabions; Drilling of boreholes; Water treatment; Use of mosquito nets; Draining stagnant water
	Kolowa East	Unpredictable rainfall patterns; Rising temperatures; Flood; Drought.	Birds invasion; Soil erosion in the farms; Siltation of rivers; Loss of livelihood; Increased level of poverty; Drying riverbeds; water scarcity; Sand harvesting; poor water quality; Waterborne diseases High rate of school dropouts; Social disorders; Environmental hazards such as oor waste disposal	Digging terraces; Use of fertilizers; Digging of ponds and water pans; Training CHVs; Indoor spraying; Clearing bushes and compounds; Draining stagnant water
	Manyatta A and B	Unpredictable rainfall patterns; Rising temperatures; Flood; Drought	Foul smell along Auji River; Water borne diseases; Destruction of settlements in Manyatta B along Auji river (Kuoyo estate); Insecurity issues; Sewage backflow in	Relocation and resettlement; Construct sewage system; Livelihood diversification; improve security; Reduce pollution.

			Manyatta peace market; Overflowing/blocked drainage systems	
	Kolowa Central	Unpredictable rainfall patterns; Rising temperatures; Flood; Drought	Destruction of road infrastructure; Increased spread of water borne diseases; Poor crop production; Spread of animal diseases; Water scarcity; Increased crop pests and diseases	Water pans; Tree planting; Planting of better crop variety
Kisumu West	South West Kisumu	Flood Drought Unpredictable rainfall patterns	Poor road accessibility; Increased spread of diseases such as malaria; Reduced crop production; Poor water accessibility and quality; Poor access to market because of road conditions; Livestock and Crop pest and diseases; Food insecurity; High food prices; Loss of livelihood; Increase in poverty	Diversification of livelihood, e.g. quarry and sand harvesting; Use of pesticides; Treatment of water; Buying water from water vendors
	Central Kisumu	Flood; Drought Unpredictable rainfall patterns	Low crop productivity; High food prices; Loss of livelihood; rising poverty; insecurity; Water scarcity; Destruction of infrastructure; Waterborne diseases; Crop/livestock Pest and diseases Increased	Diversification of livelihood; Buying of food; Use of certified seeds; Treating water; Clearing bushes and compounds; Draining stagnant water

			prevalence of malaria	
	West Kisumu	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Water borne didseases; Livestock and crop pest and diseases; Disruption of movement and communication; High school dropout; insecurity; Poor drainage; Poor infrastructure systems (bridges) in Kapuonja	Use of mosquito nets; Draining stagnant water; Treating water before drinking; tree planting; improve sewage system; water boiling and treatment.
	North West Kisumu	Prolonged drought; Rising temperature; Unpredictable rainfall patterns	Soil erosion; High rate of poverty; Drainage systems destroyed; Deforestation (Karateng sub-locations); Charcoal burning and tree felling	Tree planting, use of improved jiko; use of briquette; soil conservation
Kisumu Central	Railways	Rising temperatures; Rising lake level Flood; Drought Unpredictable rainfall patterns	Pollution from Quarry; Unpredictable rainfall patterns and distribution, Mosquito infestation; Increased waterborne diseases; prevalence of other diseases; Displacement by rising lake level	Planting of cover crops; Planting of drought resistant crops; Use of chemicals fertiliers; Opening canals; Clearing bushes and compounds; Draining stagnant water; Treating water; Boiling drinking water; Relocation and resettlement
	Migosi	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Overwhelmed sewer system; Increased erosion; Pollution; Clearing of vegetations for construction; Reclamation of	Proper sewer line and drainages; Clearing bushes and compounds; Draining stagnant water; Treating water by using

			wetlands for construction of houses; Children drowning in floods**;** Displacement by floods; Injuries; Loss of lives There is one incident where a pupil was drawn by river Auji.; Loss of properties Flash floods affect accessibility to schools;	water guard and purr
	Kondele	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Poor sanitation; Poor roads; Insecurity; Poor waste management; Poor drainage Poor performance in schools; School dropouts; Food insecurity; Rising poverty levels Increased disease frequency; cutting of trees for the construction of houses;	Construction of proper drainage system; Water treatment; use of improved crops varieties; clearing bushes, draining stagnant waters;
	Nyalenda A and B	Rising temperatures; Rising lake level Flood; Drought Unpredictable rainfall patterns	Increased diseases spread in the area such as malaria, typhoid; Poor road infrastructure and accessibility in some households; Reduction in crop production thereby enhancing food insecurity; Lack of access to clean water mostly during rainy seasons;	Diversification of livelihood; Digging terraces; Use of fertilizers; Distillation; Use of organic manure; Clearing of drainages; Use of hybrid seeds; early maturity, drought resistant and high yield; Digging of water pans; Crop rotation; Early spraying and

			displacement by rising lake level; Hippo invasion is also a problem in some of the households has also led to the destruction of the crop in the farmland. Increase in pest and diseases; Low yield; Loss of livelihood; Food insecurity; insecurity; Destruction of infrastructure;	continuous spraying; Tree planting in most of the households; Use of biogas as a source of fuel; Use of charcoal briquettes; relocation to higher ground; fencing against hippos
Muhoroni	Miwani	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Poor soil fertility, low crop production/ productivity, growing poverty; displacement by floods	Building of gabions, Tree planting, Terracing; Relocation to higher ground
	Ombeyi	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Poor roads due to flooding; Increased prevalence of malaria and waterborne diseases such as typhoid; Difficulty in accessing health facilities and schools; Reduced crop production due to drought and enhanced flooding; Displacements of communities by flood; Destruction of property such as houses and farmlands.	Development of water pans for conservation of floodwaters; Growth of drought-tolerant crops and better crop varieties such as cassava, yams and sweet potatoes; Enhancement of proper drainage; Use of treated mosquito nets; relocation to higher ground

	Masogo/ Nyang'oma	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Floods destroy of houses; loss of soil fertility; High rate of school absenteeism due to floods; Increased rate of illiteracy; Loss of livelihood; water borne diseases; Insecurity; high hospital bill; rising poverty	Digging terraces; Use of fertilizers; Digging of ponds and water pans; Treatment of water; Indoor spraying; Clearing bushes and compounds; Draining stagnant water; Treating water by using water; relocation to higher grounds
	Muhoroni/Koru	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Low crop yields; Soil erosion; Reduced soil fertility; Floods destroys crops; Food insecurity; water borne diseases; Malnourishment and other food-related diseases; High cost of production	Planting high yielding varieties; keeping improved livestock breeds; Treatment of water using water guard; Boiling of water; Rainwater harvesting; Use of mosquito nets; Clearing bushes and compounds; Draining stagnant water; Having enough toilets
Nyakach	North Nyakach	Rising temperatures; Flood; Drought Unpredictable rainfall patterns	Low crop production; Increased levels of poverty; Food insecurity; Malnourishment and other diet-related diseases; Insecurity; Biodiversity loss; Flooding; Invasion of pest & diseases; Waterborne diseases (Malaria, Cholera, Bilharzia, Typhoid)	Opening of canals; Planting of resistant crops; Use of fertilizers; Use of pesticides and herbicides; Drilling of more boreholes; Treatment of water using water guard; Boiling of water; Rainwater harvesting

	Central Nyakach	Rising temperatures Flood Drought Unpredictable rainfall patterns	Poor road accessibility; Poor road infrastructure during rainy season; Poor crop production in both wards; Increased spread of malaria and typhoid; Hippos invading crops; Increased crop pests and diseases in both wards; Scarcity of water in both wards; Reduced crop production in both wards	Most households in Central Nyakach have constructed water pans to conserve flood waters; Tree planting; fencing against hippos; building of dykes
	West Nyakach	Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	Drying of some seasonal rivers; Destruction of school structures; Destruction of access routes to school Low crop produce; Increase in livestock and crop pests and diseases; Drought and famine; Waterborne diseases (malaria, Typhoid, Amoebic dysentery) Drying of pasture; poor water quality; Siltation of rivers and dams; Destruction of habitats; Loss of biodiversity; Soil erosion;	Clearing bushes and compounds; Draining stagnant water; Using smoking method and pesticides to deal with mosquitoes; Treating water by using water guard; Boiling drinking water; Tree planting; relocation;
	South East Nyakach	Unpredictable rainfall patterns;	Poor road accessibility;	Most households in Central

		Rising temperature Drought; Flooding;	Poor road infrastructure during rainy season; Poor crop production in both wards; Increased spread of malaria and typhoid; Increased crop pests and diseases in both wards; Scarcity of water in both wards; Reduced crop production in both wards; No livestock because of cattle rustling conflicts by neighbouring tribe;	Nyakach have constructed water pans to conserve flood waters; Tree planting; Crop farming instead of livestock to avoid cattle rustling
Nyando	East Kano Wawidhi	Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	High health expenditure, growing poverty; Food insecurity; Malnourishment and other food-related diseases; Insecurity; Waterborne diseases (malaria, Typhoid, Amoebic dysentery) Migrations	Irrigation; pans to control flood; improved crop variety; water treatment, boiling of water
	Awasi Onjiko	Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	growing poverty; Food insecurity; Malnourishment and other food-related diseases; Insecurity; Waterborne diseases (malaria, Typhoid, Amoebic dysentery) Migrations	pans to control flood; improved crop variety; water treatment, boiling of water
	Ahero	Flood; Unpredictable rainfall patterns;	Destruction of crops and farmlands due to waterlogging in	Opening of canals; Planting of resistant crops;

		Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	farmlands; Increased waterborne diseases such as typhoid and malaria; Displacement of people; Destruction of property such as houses and croplands; Increased waterborne diseases; Destruction of infrastructure; Shortage of water; Livestock diseases; Food insecurity;	Use of chemicals; Digging of water pans; digging of more borehole; Use of technology to construct a small diameter borehole which doesn't collapse; Treatment of water using water guard; Rainwater harvesting
	Kabonyo Kanyagwal	Rising lake water levels; Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	Low crop productivity; destruction of houses and infrastructure; Drying rivers and ponds; Salty water; Poor quality water; Pollution of water sources due to flooding; Increased waterborne diseases; Destruction of infrastructure; Shortage of water; Increased levels of poverty; Food insecurity; Malnutrition and other diet-related diseases; Insecurity; Early pregnancies and marriages; Depression; Migration; damage of infrastructure; Drying of rivers; Pollution of water	Opening of canals; Planting of resistant crops; Use of fertilizer; Opening canals; Elevation and piping of boreholes; Treatment of water using water guard; Boiling of water; Rainwater harvesting; Merging schools; Construction of floodwater drainage; building bridges

			sources due to flooding; inter-community conflicts over water	
	Kobura	Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	Displacement of people; Increased crop pests and diseases; Drying of water sources such as rivers and wells; Poor crop growth leading food insecurity; Destruction of crops lands leading to food insecurity; Increased spread of diseases such as malaria; Apida dam which has led to high flooding in parts of Kochogo sub-location and accidents leading to deaths in the area; Poor road infrastructure due to heavy rainfall that has led to muddy roads; Poor accessibility to schools and health centres during the rainy season	Opening of canals; Planting of resistant crops; Use of fertilizer; Opening canals; Elevation and piping of boreholes; Treatment of water using water guard; Boiling of water; Rainwater harvesting; Merging schools; Construction of floodwater drainage; building bridges
Seme	West Seme	Unpredictable rainfall patterns; Rising temperature Drought;	Human-wildlife conflict; Soil erosion; Poor sanitation (inadequate construction of toilets); Low productions; Lack of pastures; Diminishing fish production; Water scarcity;	Tree planting; Planting of drought-resistant crops; Zero grazing; irrigation; water pans; Construction of footbridge; Construction of small gabions;

			Waterborne diseases; Increase in respiratory diseases; Increase in malaria disease; Waterborne diseases	
	Central Seme	Unpredictable rainfall patterns; Rising temperature Drought;	Low yield; Waterlogging destroys crops; Waterborne diseases Displacement from farms; Crop pest and diseases; Water scarcity; Destruction of infrastructure; Shortage of water	Diversification of livelihood; Digging terraces; Use of modern agriculture; Early warning system; Control of soil erosion
	East Seme	Unpredictable rainfall patterns; Rising temperature Drought; Flooding;	Prevalence of malaria; Human-wildlife conflict (monkeys which destroy crops in the farms; Poor waste disposal mechanisms (burning wastes) ; Low productivity during drought periods; Fuelwood crisis during rainy seasons	Use of clean cooking solutions (improved stoves and clean fuel); clearing stagnant water;
	North Seme	Unpredictable rainfall patterns; Rising temperature Drought;	Low crop yields; Livestock diseases and pest Food insecurity; Decrease in water quality; Reduction in water levels of rivers; Drying of springs	Planting of resistant crops; Use of fertilizers; Use of pesticides and herbicides; Drilling of more boreholes; Treatment of water using water guard; Boiling of water; Rainwater harvesting