ASSESSMENT OF COMMUNITY RESILIENCE TO IMPACTS OF CLIMATE CHANGE RELATED DISASTERS ON THE ENVIRONMENT IN LOWER NYANDO RIVER BASIN, KISUMU COUNTY, KENYA

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A Thesis Submitted to the Postgraduate Studies of Kabarak University in Partial Fulfillment for the Award of Doctor of Philosophy in Environmental Studies.

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ABSTRACT

Residents of lower Nyando River Basin, Kisumu County are predisposed to flooding and drought cycles, whose impacts are exacerbated by climate change. These phenomena leave trails of destruction, which negate cumulative efforts by the communities to maintain sustainable livelihoods and ecosystem health, compromising their resilience to

Climate Change Related Disasters (CCRDs). The study examined resilience of households to the impacts of CCRDs on the environment in lower Nyando River Basin, Kisumu County, through six specific objectives: i) to determine the Impact of CCRDs on the Environment of households, ii) to determine the resilience of households to impacts of CCRDs on the environment, iii) to determine the influence of Impacts of CCRDs on the environment on the coping mechanisms, iv) to establish how the Impact of CCRDs on the environment influences recovery of households, v) to examine the influence of socioeconomic factors on the households' ability to cope with impacts of CCRDs on the environment and vi) to investigate the influence of socioeconomic factors on households' ability to recover from the impacts of CCRDs on the environment. Resilience was assessed as a function of coping and recovery. A descriptive research design was adopted. The research sampled three divisions: Kadibo, Nyando and Lower Nyakach which were selected purposefully due to being prone to both floods and drought. A proportionate sample of 374 household heads was systematically selected from a target population of 162,162. Data was collected using a household questionnaire, key informants' guide and observation schedule. Data analysis was conducted using Statistical package for Social Sciences. Descriptive statistics; frequency distributions, means, percentages and inferential statistics; ANOVA, Simple regression and multiple regression tested at alpha $p < 0.5\%$) were used to test the six hypotheses. The results accepted two null hypotheses and rejected four null hypotheses and concluded that Impact of CCRDs on the environment is high, the resilience of households to impacts of CCRDs is below threshold, socioeconomic factors influence resilience to impacts of CCRDs with age and gender influencing resilience significantly and sizes of land influencing recovery significantly. The study recommends the following: a landscape approach to managing environmental hazards in order to reduce impact downstream, an up scaling of coping mechanisms, Policy consideration of socioeconomic factors: age, gender and land sizes in disaster management, enhancement of extension services, and communal approach to resource management to enhance resilience-proofing against CCRDs.

Keywords: ***Resilience, CCRDs, Impacts, Coping, Recovery, Socioeconomic factors.***

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LIST OF ABBREVIATIONS AND ACRONYMS

CA: Conservation Agriculture

CAS: Complex Adaptive Systems

CCA: Climate Change Adaptation

CCRDS: Climate Change Related Disasters

CCR: Climate Change Related

CHV: Community Health Volunteers

CSOs: Combined Sewer Overflows

DRM: Disaster Risk Management

DRR: Disaster Risk Reduction

EMCA: Environment Management and Coordination Act

ENSO: El Nino-Southern Oscillation

GOK: Government of Kenya

HHs: Households

HHHs: Household Heads

HHQ: Household Head Questionnaire

IGAD: Intergovernmental Authority on Development

IPCC: Intergovernmental Panel on Climate Change

IFRC: International Federation of the Red Cross and Red Crescent Societies

ISDR: International Strategy for Disaster Reduction

KNBS: Kenya National Bureau of Statistics

KI: Key Informant

KCIDP: Kisumu County Integrated Development Plan

LAC: Latin America and the Caribbean

LDCs: Least Developed Countries

LVBC: lake Victoria Basin Committee

NCCRS: National Climate Change Response Strategy

NCCAP: National Climate Change Action Program

NDMA: National Drought Management Authority

NGOs: Non-Governmental Organizations

OG: Observation Guide

PHD: Pubic Health Department

RCS: Red Cross Society

SES: Socio-ecological Systems

TOC: Total Organic Carbon

ToC: Theory of Change

UNCCC: United Nations Conference on Climate Change

UNISDR: United Nations International Strategy for Disaster Risk Reduction

OPERATIONAL DEFINITION OF TERMS

Assessment: is the act of judging or forming an opinion about something (Oxford Advanced learners Dictionary, 2015). In this study, assessment is operationalized as gauging the resilience of households to impacts of floods and drought on their environment.

Adaptation in human systems, it is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems it is the process of adjustment to actual climate and its effects: human intervention may facilitate adjustment to expected climate (IPPC, 2012). In this study, adaptation refers to a consistent way of adjusting to actual changes in climate related floods and droughts.

Climate change refers to a change in the state of climate that can be identified (such as by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPPC, 2012).In this study, climate change refers to palpable changes in rainfall and temperature patterns over long periods of time.

Climate Change Related Disasters: In the study this has been operationalized as threats to the system from climate change related sources. This includes both shocks, such as a flood or drought, and stresses, such as increasing rainfall variability.

Community is a group of diverse individuals in a shared geographical area, who have common interests, are linked by dynamic socio-economic interactions, and engage in collective action (Miles, 2015). In this study, community refers to a group of diverse individuals in a shared geographical area demarcated by administrative boundaries.

Community Resilience-is the ability of communities to resist, absorb, accommodate and recover from the effect of hazards in a timely and efficient manner and find stability in a new changed state through learning from past experience (Parsons *et al.,* 2016). In this study, community resilience is defined as the ability of community to absorb, accommodate and recover from the effects of floods and drought on their soils and water sources to the extent of being able to provide the environmental goods and services.

Coping refers to the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term. (IPPC, 2012). In this study, coping refers to the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions on soils and water sources brought about by floods and droughts.

Coping capacity: refers to the ability of people, organizations, and systems, using available skills, resources and opportunities to address, manage and overcome adverse conditions (IPPC, 2012). In this study, coping capacity is operationalized as the ability of people, organizations, and systems, using available skills, resources and opportunities to address, manage and overcome adverse conditions on soils and water sources brought about by floods and droughts.

Disaster: Severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery (IPPC, 2012). In this study disaster is a flood or drought that seriously disrupts the structure and functioning of soils and water sources leading to human, material, ecological/environmental and economic losses.

Disaster resilience: Is the ability of individuals, communities and states and their institutions to absorb and recover from shocks, whilst positively adapting and transforming their structures and means for living in the face of long-term changes and uncertainty (OECD, 2013). In this study disaster resilience refers to the ability of households to collectively engage interventions that ultimately lead to sustainability of the natural environmental (soil and water sources) functions after flood and drought episodes

Drought: Is defined as a period of abnormally dry weather long enough to cause a serious hydrological imbalance (IPPC, 2012).In this study, drought is defined as a deficiency in precipitation over an extended period, usually a season or more, resulting in water shortage resulting in adverse impacts on vegetation, soils, water sources, animals and/or people.

Environment is the external surroundings in which a plant or animal lives and which tend to influence its development and behavior (Collins Concise English Dictionary, 7th edition 2008). In this study environment is operationalized as soils and water sources.

Flood: The overflowing of the normal confines of a stream or other water body, or the accumulation of water over areas that are not normally submerged (IPPC, 2012). In this study, a flood is defined as an overflow of water onto normally dry area caused by rising water in an existing waterway such as a river or stream causing adverse impacts on vegetation, soils and water sources, animals and/or people.

Hazard is the potential occurrence of a natural or human-induced physical event that may cause loss of life, injury, or other adverse health impacts, as well as damage to and loss of property, infrastructure, livelihoods, service provision, and environmental resources (IPPC, 2012). In this study hazard refers to the potential occurrence of a flood or drought that may cause damage to soils and water sources.

Household is a group of persons who reside in the same homestead/compound but not necessarily in the same dwelling unit, have same cooking arrangements and are answerable to the same household head (Kenya National Bureau of Statistics-KNBS, 2010). In this study a household is a group of persons who reside in the same homestead/compound and is answerable to the senior most person.

Impact is defined as effects on natural and human systems (IPPC, 2012). In this study, Impact is used to describe the cumulative effects of CCRDs (floods and drought) on Soils and water sources.

Recovery is defined as "the act or process of becoming stronger again. (Oxford Advanced learners Dictionary, 2015).In this study, recovery is defined as "the restoration, and improvement where appropriate, of soils and water sources following impacts of floods and drought.

Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, ensuring the preservation, restoration, or improvement of its essential basic structure and function (IPPC, 2012). In this study, resilience is defined as the ability of households to deal with impacts of floods and drought by embracing coping mechanisms that restore their soils and water sources back to their structural and functional states.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter gives an overview of the study by describing the background of the study area followed by a precise statement of the problem, purpose of the study, the objectives of the study, the hypotheses, significance, scope, limitations and assumptions of the study.

1.2 Background of the Study

Globally, studies have demonstrated that most natural disasters that afflict humanity are related to severe weather and extreme climate events. IPPC, (2014) amongst others recognize the increased risk of floods due to climate change and increased climate variability such as El Niño in poor developing countries.

In the United States of America, climate change related disasters have occurred such as Hurricane Katrina (Witty, 2005). This hurricane was reported as the most destructive and costly in U.S. history, causing damages worth $108 billion, 1,833 deaths and millions of others were left homeless along the Gulf Coast and in New Orleans following the flooding that ensued according to the National Oceanic and Atmospheric Administration (NOAA). Asia has not been spared disasters emanating from severe weather and extreme climate. Such cases have been reported in Odisha state in Eastern India which suffers from climate induced disasters namely cyclones, floods and drought due to its geographical location, climatic conditions, and high dependence on natural resources, limited capacity to adapt to the changing climate and weak climate and disaster policy (Patel, 2016). The people here adopt various localized coping mechanisms and adaptation strategies, which depend on their perceptions about extreme events and the impacts of the events. The success of the coping mechanisms and adaptations is however compromised by the peoples' vulnerabilities, which have not been adequately addressed. This is similar to the situation reported in Indonesia where the capability of people to deal with floods is also influenced by socio-economic characteristics (Mone, 2010).

A synthesis of the changes in risks of various categories of weather disasters by Kron, Petra and Kundzewicz (2019) depict a picture of rising damage and fatalities arising from extreme weather events in Europe where floods (mostly river) were reported in Italy, France and Switzerland in 2000, in the upper Elbe and Danube catchments in 2002 and 2013, along the lower Danube in 2006, in the United Kingdom in 2007, in the Adriatic region in 2014 and in Germany and France in 2016. In the same breath, severe heat waves and droughts marked the summers of 2003, 2010 and 2018 while large-scale wildfires burned in southern and Eastern Europe in 2007, 2010 and 2017. Accompanying these events were damages ranging from casualties, destruction of property, loss of farmlands amongst other impacts.

In Latin America and the Caribbean (LAC), floods and storms account for the clear majority of disasters and that the trend is rising substantially, from a little more than 100 in 1970–79 to around 400 in 2000–2008 (Rossing and Rubin, 2019). According to this article, the type and frequency of natural disasters and their impact vary widely across Latin America and the Caribbean with most of the weather-related hazards occurring in South America followed by Central America.

A study by Gentle and Maraseni (2012) in the remote Jumla District of Nepal to explore how climate change was affecting the livelihood of local communities showed that, changing weather patterns had significantly challenged the livelihoods of a community: changing types of crops grown and the farming calendar, experiencing resource degradation (deforestation and loss of pasture for livestock), food scarcity, lack of basic services, and increasing social inequalities. In this district, temperature records over a period of 30 years, showed a gradual increase in both maximum and minimum temperatures and also high variability in the rainfall patterns. The temperature changes and climate variability had a significant effect on agriculture. The communities appeared to be struggling to adapt to their changing environment with their limited knowledge, poor assets and inadequate external support. They had adopted common practices of adaptation of agricultural production like crop diversification and selection of drought resistant crops. These responses were autonomous, short term and used on an ad hoc basis. Within the agricultural sector, poor households had limited options due to limited land ownership, decreasing numbers of livestock and depletion of forest resources; however, the well-off people, who owned irrigated land, were introducing some vegetables and other crop varieties. Poor people were coping by using household efforts only and limited support from the local institutions, while the medium and well-off households were utilizing household, community, government and market services for the diversification of livelihood resources and options.

In the Horn of Africa, deterioration of the environment has continued despite discernible efforts by IGAD member states to develop and implement sustainable development strategies in the form of national conservation strategies, national environment action plans and international conventions (IGAD, 2016). A study cited in Feleke, Berhe, Gebru and Hoag, (2016) indicated that climate change is expected to bring about significant yield losses between 3 and 30 % and extinction of land, plants and animal species between 15 and 37 % by 2050 unless remedial measures are taken into account. In Africa, disasters remain one of the main challenges facing nations of the developing world, as they not only cause high mortality and destruction of property, changing of landscape and biodiversity, but also damage local economies that are in process of formation and thwart development goals. The Increasing frequency and intensity of extreme weather events and progressive slow-onset climate-related threats will worsen the vulnerability of poor households and communities to disasters in developing countries, particularly in Least Developed Countries (LDC's), many of which are situated in Sub Saharan Africa and which lack the capacity to cope (Opondo,2013).The increase in the frequency of climate change extreme events such as droughts and floods has increased the pressure on water and arable land, two critical inputs in agricultural production (Rojas, Rahlao, Alfaro, Engel, Dubeux, Gomez, Gutman, Jarvis, Kebreab and Rosales, 2014). Changing climatic conditions are affecting soil moisture with a consequent possibility of affecting crop production (Mabe, Sarpong and Asare, 2012). In a study to estimate the adaptive capacities of farmers to climate change adaptation strategies and their effects on rice production in the Northern Region of Ghana. Mabe *et al.*, (2012) established that farmers who had better capacities to adjust to climate change harvested more bags of rice and went on to propose that improved extension services would enhance rice farmers adaptive capacity. Sheep and Goat farmers in Southern and Central Tigris, Ethiopia also reported changes in climate and variability as increased temperatures and decreased rainfall. They employed various adaptation strategies such as marketing during shock and home feeding in order to cope with the drought (Feleke *et al.*, 2016).

In Rubanda district of Southwestern Uganda, temperature was found to have increased significantly whereas a decreasing trend in rainfall had been observed over the past 40 years. Farmers here perceived climate variability as the cause of decline in agricultural productivity impacting on food security (Byamukama, Bello and Omoniyi, 2011). Strategies Adopted by Farmers in Response to Climate Variability and Change in Rubanda District included: Awareness on Climate Variability and Change in the study area, Food Aid from Support

Organizations and Government, Improved Crop Varieties and Animal Breeds, Improved Crops and Animal Variety Support from Organizations and Government, Water Supply Support from Organizations and Government, Rain Water Harvesting, Food Storage and Tree Planting. They recommended that extension services amongst others should be directed towards interventions to improve agricultural productivity by addressing issues concerning aspects of climate variability and change that constantly affect the dimensions of food security.

The Kenya National Adaptation Plan (KNAP, 2016) acknowledges the influence of global, regional and localized climate conditions such as the El Niño, Southern Oscillation on local incidences of drought and flooding in the country over decades. Floods and droughts have been documented as indicators of climate change and are reported as some of the major disasters that afflict Kenyans and which are a recurrent phenomenon (Kenya Disaster Risk Profile, 2014). In Kenya for instance, due to droughts, the country's famine cycles have reduced from 20 years (1964- 1984), to 12 years (1984-1996), to two years (2004-2006) and to yearly (2007/2008/2009), necessitating the Government's distribution of 528,341.77 metric tons (MT) of assorted foodstuffs worth Ksh. 20 billion over the last five years alone to feed a population of between 3.5 million and 4.5 million people annually (NCCRS, 2010). However, these flood hazards turn into disasters only in few places in the country. The most affected places are the floodplains of the major rivers such as the lower Tana River, the lower Nzoia River at Budalangi and the lower Nyando River at Kano Plains (Opere, 2013). The Lake Victoria Basin in western Kenya is one of the most flood-prone regions in the country (LVBC, 2011). Significant changes in the occurrence of floods were reported by 75% of respondents in a study undertaken in Bunyala district of Western Kenya (Opondo, 2013). This was attributed to climate change. Some respondents reported that River Nzoia flooded up to 5-6 times in a year compared to earlier years when it used to flood once in a year and with limited impacts that were sorted out by digging drainage canals since water would not last for more than three days. This was unlike the floods of 2011, which caused lots of crop damage, loss of livestock and grazing fields culminating in lack of food and increased poverty levels in many households. The households engaged in erosive coping strategies in the long term that had serious implications on the security of their livelihood. IGAD (2016) asserts that factors that affect land productivity directly impact the welfare of the population directly especially in populations that derive their livelihood from agriculture.

Kisumu County has not been spared from flood and drought hazards and rainfall variability that are indicators of climate change. In recent years, floods in the Nyando River basin have resulted in negative impacts, ranging from loss of human lives and livestock to widespread destruction of crops, houses, public utilities and disruption of various economic activities (Nyakundi, Stephen, Isaac and Andre, 2010). Prolonged drought due to below normal precipitation in Nyando River Basin has also contributed to immense negative effects in the basin such as decreased water volume in rivers, dry wells, death of livestock and loss of livelihoods dependent on water. Nyakundi (2010) observed that most of the indigenous actions were taken at the household level to adapt to the health risks posed by floods in Nyando Basin, Western Kenya. Some of the Coping mechanisms included skipping meals support from relatives, building houses on raised lands or earthen platforms and sailing in canoes to safer grounds amongst others. Aid dependency during flood disasters was found to have significantly contributed to decreased ability cope (high risk, $p=0.026$; low risk, $p=0.003$). This study concluded that there was a wealth of traditional flood knowledge, which indicated some ability of the locals to be resilient. Higher perception of risk did not necessarily translate into better preparedness. Most indigenous coping actions were taken at the household level to adapt to the health risks posed by floods. The dependency syndrome and its pitfalls for creating less resilient communities were evident in this community. Masese, Neyole and Ombachi, (2016) also reported that several coping strategies such as labor migration, using children at work and increasing consumption loans appeared to be pushing poor communities towards indebtedness and a vicious cycle of poverty with additional vulnerabilities and risks in the lower Nyando River Basin. Obiayo, Stanley and Charles, (2016) investigated the Influence of floods on community livelihood sustainability and development in Nyando River Basin, and established that floods wreak havoc on the maize and bean crops leading to food insecurity, school children stayed out of schools longer, more people accessed water from open sources posing health risks and inadequacy of sanitary facilities, shelters were also destroyed. Their study focused on effects of floods on crops and shelters but did not focus on the influence of floods on soils and water sources, which is the bedrock of the livelihoods. Little mention was made of the coping mechanisms but they proposed several interventions including Village Savings and Loan Schemes, Development of calendars to guide farming activities in the agro-ecological zone by government and humanitarian agencies, construction of food stores on higher grounds to support grain banking and introduction of new technologies to boost crop farming in the Nyando River Basin. A study conducted by Masese *et al*, (2016) on the impacts of floods on education, sanitation and flood induced health problems on three locations vulnerable to flooding in Wawidhi, Kakola and Ombeyi within the lower Nyando River Basin, showed that floods cause loss of learning hours, poor academic performance, high pupil absenteeism, poor syllabus coverage, and a high turnover of teachers. Physical health impacts of floods highlighted include overwhelming psychosocial effects, water-borne and respiratory illnesses. Sanitation facilities became unusable during and after floods. Likewise, no mention was made of the impact of floods on the soils.

Sarner and van der Geest (2013) in Opondo (2013) acknowledge that climate change impacts may still occur despite mitigation and adaptation measures and refer to these as ‘loss and damage’. Communities in the study area therefore ought to be able to flourish in the face of disaster risk by building resilience. By measuring trends or patterns in resilience, the success of measures for enhancing resilience can be determined (Kenya disaster and risk profile, 2014). As much as these communities living in Nyando River Basin may have their inherent resilience, other factors like poor planning leading to *ad hoc* settlements and developments may weaken this (Khailani and Perera, 2013). A high population density can also increase the exposure and the vulnerability to disasters, when the people and the assets exposed are not settled in a planned and sustainable manner. When this is the case, a hazardous event can lead to increased damage and loss.

According to Thorlakson (2011), soils and water sources (referred to here as the natural capital) are affected in times of floods and drought and this has an effect on their productivity and other services. The outcome is low soil organic matter content, which results in low water holding capacity and may lead to soil erosion by runoff water during the rains. This can also impact negatively on the microbial activities in the soil. The application of well rotten manure or compost would improve the organic matter content in the soil and hence supplement the soil nutrients, improve soil structure, water retention capacity and soil microbial activities (NAAIAP, 2014). Increasing intensity of Impact may also stretch communities’ ability to cope and adapt leading to erosion of family resources that would otherwise be put to other quality life enhancing uses. In the lower River Nyando Basin, negative perceptions, poor adaptive capacity, inadequate preparedness, and cultural attributes are contributors of increased vulnerability and hence reduced resilience to climate related hazards (Opondo, 2013; Obiayo, 2010; Okayo, Peter and Stanley (2015). However few studies have been conducted addressing effects of drought and floods on the soils and water sources, with a view to determining if the current coping strategies employed are adequate to build resilience in the livelihoods of the communities. There is little documentation available to this effect especially on how CCRDs Impact on soils and water sources and how successfully, the communities in lower Nyando River Basin are addressing these effects. An assessment of how the Impact of CCRDs influences the coping capacity and recovery in conferring resilience to the socio-ecological systems of communities in the lower Nyando River Basin in order to guarantee sustainable livelihoods and ecological health of the systems will yield critical information in the gaps and help to inform policy development and interventions on climate change adaptation. All these studies did not address impacts of CCRDs on soils and resilience of the study community living in Lower Nyando River Basin. Due to these gaps and scanty information, the researcher was motivated to establish these claims and fill the gaps in the study area.

1.3 Statement of the Problem

Lower Nyando River Basin frequently experiences floods and drought and these affect the livelihoods and ultimate wellbeing of the communities living therein. The communities in this area draw their livelihoods from the natural capital namely soils and water sources through subsistence farming and traditional livestock keeping for their own household consumption. The frequent floods and drought erode the natural capitals' ability to support these livelihoods rendering the communities less able to cope and recover from the impacts of Climate Change Related Disasters (CCRDs) with subsequent poor resilience (Opondo, 2013). The study area has had frequent climate change related disasters floods and droughts, which have devastated the livelihood of the community and from other studies, there is no scientific documentation on the extent of the problems caused by CCRDs and recommended steps for mitigation. Due to this fact, the researcher was motivated to carryout research study with the aim of finding the impacts of the problems and make recommendations on how the community may cope with the recurrent problems hence build resilience in the systems.

1.4 Broad Objective

The broad objective of this study was to assess the community resilience to Impacts of Climate Change Related Disasters namely floods and drought on the soils and water sources in Lower Nyando River Basin, Kisumu County, Kenya.

1.5 Specific Objectives

The study was guided by the following specific objectives:

i. To determine the Impact of CCRDs on the Environment of households in lower Nyando River Basin.
ii. To determine the resilience of households in lower Nyando River Basin, Kisumu County to the impact of CCRDs on the environment.
iii. To determine the influence of Impact of CCRDs on the environment on the coping mechanisms of households in lower Nyando River Basin, Kisumu County.
iv. To establish how the Impact of CCRDs on the environment influences recovery of households in lower Nyando river basin, Kisumu County.
v. To examine the influence of socioeconomic factors on the households' ability to cope with impacts of CCRDs on the environment in lower Nyando river basin, Kisumu County.
vi. To investigate the influence of socioeconomic factors on households' ability to recover from the impacts of CCRDs on the environment in lower Nyando river Basin Kisumu County.

1.6 Hypotheses

The study will be guided by the following hypotheses:

H_{01}: There is no significant difference in Impact of CCRDs on the environment of households in lower Nyando River Basin Kisumu County.

H_{02}: There is no statistical significant difference in resilience of households to impact of CCRDs on the environment in lower Nyando River Basin Kisumu County.

H_{03}: Impact of CCRDs on the environment has no statistical significance on coping mechanisms of households in in lower Nyando River Basin Kisumu County.

H_{04}: Impact of CCRDs on the environment has no statistical significance on the recovery of households' in lower Nyando River Basin Kisumu County.

H_{05}: There is no statistical significant influence of socioeconomic factors on households' ability to cope with effects of CCRDs on the environment in lower Nyando River Basin Kisumu County.

H_{06}: Socioeconomic factors do not significantly influence recovery of households from the effects of CCRDs on the environment in lower Nyando River Basin Kisumu County.

1.7 Significance of the Study

Floods and droughts, associated with extreme climate events, have very devastating effects on almost all socio-economic activities and are very common in many parts of Africa (Opere, 2013). The regular occurrence of floods and droughts has continuously undermined economic development in the affected areas exacerbating poverty levels. It has been established that the alternating cycles of droughts and floods do not only destroy the livelihood sources but also severely undermine the resilience of the people living in the affected areas (KRCS, 2012). This has been observed in lower Nyando River Basin, where floods are perennial each time taking back years of development and costing the government millions of shillings in reconstruction and recovery (Kenya National Disaster profile). Many studies have been conducted on vulnerability and adaptation to climate change in this area with much emphasis being laid on the secondary impacts (outcomes or consequences) of floods on the physical infrastructure, education, livelihoods and health of the communities in the study area and how they deal with these. However little attention has been given to the primary impacts of floods and drought on the natural capital (soils and water sources) and the interventions made by the communities. Furthermore, there is a knowledge gap on the extent to which the magnitude of the impacts influences the coping mechanisms and recovery by households. The findings of this study will serve as baseline for future researches targeting on building resilience of households in the study area. It will also inform policy directed at improving environmental health and cushioning climate-dependent livelihoods by addressing issues that influence the success of coping and ultimate adaptation to CCRDs by the communities in lower Nyando River Basin.

1.8 Scope of the Study

This study examined community resilience to Impacts of CCRDs on the environment with respect to floods and drought in the lower Nyando River Basin. The environment was limited to soils and water sources within the study area. It focused primarily on examining the demographic and social characteristics of households in lower Nyando River Basin, impacts of CCRDs on the environment (soils and water sources), and the influence of social factors on the households ability to cope with and recover from the effects of CCRDs. Socioeconomic factors are diverse but the study concentrated on age, level of education, gender (sex) and size of land of the respondents. The survey was conducted in the dry season between December 2018 to January 2019 and also in the wet season between the months of March to April 2019.

1.9 Limitations of the Study

Limitations are matters and occurrences that arise in an experiment or study that are totally out of the researchers' control but may affect the end result of the investigation. They are potential weaknesses in the study and which are out of control of the researcher. The study had several limitations.

i. Respondents may have been biased in their responses depending on their social orientation. To mitigate this, various tools/methods (questionnaire, Key Informant Interviews and observations checklists) were used to compare and validate the answers.

ii. Most household heads were of limited education (primary level of education). The respondents mainly spoke and understood the local *Luo* language yet the original questionnaire was in English. These two factors posed a challenge in translating some scientific terminologies. To surmount this; a pilot study was carried out and the results used to provide the enumerators with appropriate and standardized translations in Swahili and *Luo* for important concepts and technical words.

iii. The administrative boundaries of the sub-counties changed since the promulgation of the new constitution in 2010 such that by 2013, records previously held at the District headquarters were devolved accordingly to the new counties and sub-counties. Secondary data of crops production was particularly difficult to get with the custodians reporting missing data due to change of offices. Consequently crop production data gathered was unavailable and where it was available, it was discontinuous with many years' production details missing. In this study, crops data was available for five years only. Five years is not adequate in climate change studies and hence this data could not have been used to support any observed changes on soil fertility and water insufficiency.

iv. The timing of daily livelihood activities of respondents was a bit of a challenge since, most respondents were occupied with activities like market visits, grazing animals, and working on the farms, firewood collection and local village meetings (*"chamas*"). Enumerators therefore sometimes had to wait for them until about 11.00 a.m. or later in the afternoons, so as not to interfere with respondents' household activity schedules. This resulted in delays in completing the questionnaire survey.

v. During the rainy season, rains in the afternoon disrupted the survey and this compounded the transport problem since most roads were impassable. Repeat visits had to be scheduled to conduct the set numbers of questionnaire interviews.

1.10 Assumptions

The following assumptions were postulated:

i. At least over 90% of the respondents were honest in responding to questions. Assuring interviewees of anonymity and confidentiality mitigated this.

ii. The key informants allowed access of relevant documents and records, which were availed and verified.

iii. The communities in the lower Nyando River Basin were similar in terms of economic pointers. This was evident from the type of shelters and farm sizes owned by the households. A few outliers were encountered but their responses on impacts, coping and recovery did not bring out any significant differences.

iv. The study area had similar production systems and so the interventions can be applied uniformly across the study area. Most of the households are subsistence farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter examines the existing knowledge, and knowledge gaps in respect to concepts such as resilience, Climate Change Related Disasters (CCRDs), Prevalence of CCRDs, overview of Impacts of CCRDs, resilience to impact of CCRDs on soils and water sources from the lens of coping capacities and recovery, and finally provides the theoretical framework and operationalized conceptual framework of study variables in play.

2.2 Climate Change Related Disasters

Any change in weather patterns observed for several years is termed as climate change and it may cause global warming, droughts, flooding and depletion of natural resources. The observed dynamic climatic condition over the past 30 years is clear on every continent. Climate change is already modifying the frequency and intensity of many weather-related hazards (IPCC, 2014) as well as steadily increasing the vulnerability and eroding the resilience of exposed populations that depend on arable land, access to water, and stable mean temperatures and rainfall (UNISDR, 2015a). The observed change in climatic conditions over the past 30 years is clear on every continent with the key indicators of climate change, including rise in sea levels, rise in temperature and drought days, expanding outside the normal ranges of frequency, intensity and location (Nolan, Michael and Smith, 2015). The trio reported that recent extreme weather events such as hurricanes in the United States, floods and storms in Europe, typhoons in Asia, droughts in Africa, and bushfires in Australia have served to remind of the impacts of climate change and in many cases, highlighted shortcomings in preparedness and disaster response.

Barnwell, Rutherford, Mackey, Street and Chu (2018) classified climate-sensitive hazards as hydrological (such as flood and rainfall-triggered landslide), climatological (such as drought and wildfire), biological (for example, relevant climate-sensitive diseases such as dengue, cholera, malaria, etc.) and meteorological hazards (such as temperature extremes, severe storms, heat waves in India) and noted that the impact of these hazards with respect to the exposure and vulnerability of a community can result in climate-sensitive disasters. The disasters could also be natural or anthropogenic depending on the origin (Guha-Sapir, Vos, Below, Ponserre and Louvain, 2012). Sauerborn and Ebi (2012) pointed out that floods and drought are disasters, which can be influenced by Climate Change. Thorlakson and Neudfeldt (2012) also referred to both climate-related shocks, such as floods and droughts, and longer-term climate stresses, such as increasing rainfall variability as ‘Climate-related hazards’.

Opere (2013) noted that precipitation plays a critical role in disasters in the water resources sector where on one hand, its abundance can lead to disasters such as flooding, water pollution, soil erosion, dam breaks, and water-related disease outbreaks and famine and on the other hand, its scarcity in areas, which ordinarily receive it, can lead to drought, water scarcity, loss of vegetation, loss of livestock and wildlife, famine and general suffering of people living in the affected areas. Rainfall, floods, drought and raised temperatures have been used as climate change markers in studies of climate change awareness (Ajuang, Album, Bosire, Dida and Anyona *et al.,* 2016). (Warner 2012,) examined climate stressors, such as droughts, floods, glacier retreat, cyclones, sea-level rise, salinity intrusion and coastal erosion in nine LDCs in a study aimed at understanding the impact of climate change beyond coping and adaptation known as 'loss and damage'. Rainfall variability is the other indicator of climate change as observed by farmers in the lower and middle Nyando (Thorlakson, 2011). From the examples listed herein, it can be concluded that floods, drought and rainfall variability are indicators or markers of climate change. Floods and drought are therefore climate change related hazards and they have the potential to cause climate change related disasters (Kenya disaster risk profile, 2014). Evidence of climate change is now more pronounced through the alternating cycles of droughts and floods, such as has been experienced in Kenya in 2004, 2006 and 2009 where droughts were interposed with floods (Kenya Red Cross Society, 2012). The frequency of occurrence and severity of floods and droughts have been increasing over time. It is reported that the frequency of drought increased from once in every 10 years in 1970s, to once in every 5 years in 1980s, once in every 2-3 years in 1990s and every year since 2000 (Huho and Kosonei, 2014).

Kenya is highly vulnerable and exposed to several disaster crises, which negatively impact social and economic development, and are being exacerbated by climate variability and change. These crises have derailed societal development and negatively influenced the achievement of the Millennium Development Goals (MDGs) and Kenya's Vision 2030. Between 1993-2010 the international database on disasters showed that 73 disaster events (covering drought, epidemics, flood, landslide and a tsunami) occurred and affected a cumulative total of over 48 million people (averaging 2.9 million people annually). The prevalence of climate related hazards in Kenya has been rated at 29% floods, 24% drought, 43% epidemics (most of which are related to floods), 2% Famine and 2% windstorms (Opere, 2013). Kenya's fiscal exposure to natural disasters is significant. Repeat disasters cause large economic losses to the country on a recurrent basis. In 2004 a tsunami caused by an earthquake in the Indian Ocean struck the east coast of Kenya, estimated to cost the region US$100 million. Opere (2013) noted that while floods seem to have about the same prevalence in Kenya as droughts, droughts affect many more people than floods but due to the existence of generally functional drought management strategies in the country, droughts disasters are not as devastating as flood disasters and hence the urgent need for the development of flood disaster mitigation strategies in the country. These comprise droughts, floods and landslides. In some parts of the country, particularly the northern corridor, droughts are a norm rather than exception. Though less frequent compared to droughts, when they occur, floods displace thousands of people and lead to massive loss of life and property. Raburu, Okeyo-Owuor and Kwena (2012) propose the need for appropriate adaptation and mitigation measures to minimize the impacts of unpredictable climatic changes. The direct and indirect impacts of climate change are already being felt across the country and there is a high possibility of increasingly severe changes in the future if unprecedented measures are not taken to reduce GHGs emissions. Natural disasters associated with climate variability and change can cost huge losses in GDP. For instance, the 1999 and 2000 droughts in Kenya caused damages equivalent to 2.4% of GDP. The same report predicts that the cost of climate change in Africa could be as high as 7-10% of GDP by 2100 (NCCRS, 2010).

In Kenya, floods hazards are recurrent phenomena. However, these hazards turn into disasters only in few places in the country. The most commonly affected places are the floodplains of the major rivers such as the lower Tana River, the lower Nzoia River at Budalang'i plains and the lower Nyando River at Kano Plains (Opere, 2013). The Lake Victoria Basin in western Kenya is one of the most flood-prone regions in the country. In recent years, floods in the Nyando River basin have resulted in negative impacts, ranging from loss of human lives and livestock to widespread destruction of crops, houses, public utilities and disruption of various economic activities (Nyakundi *et al.,* 2010). Prolonged drought due to below normal precipitation in Nyando River Basin has also contributed to immense negative effects in the basin. A Study conducted in Nyando District to assess the vulnerability to climate change in Lake Victoria Basin revealed that environmental resources like trees and grass cover were highly vulnerable due to fuel needs, clearing wooded areas for farming and use of these areas for building and creation of new homes due to population increase (LVBC, 2011). Grass cover could suffice for ground cover. If ground cover is vulnerable, then the soils would be equally vulnerable to climate change and its vulnerability needs to be investigated.

Although Kenya has suffered from periodic droughts throughout its recorded history, their magnitude and severity has increased in the recent past as a result of global climate change especially in the arid and semi-arid lands (ASALs), which make up more than 80 per cent of Kenya's land mass (Country Program Paper, 2012). This paper chronicled drought episodes and their impacts in Kenya over the last decade in 2001, 2003, 2006, 2009 and 2011. The overall effects of the 2008-2011 droughts in Kenya have been estimated at US$12.1 billion, a reduction of GDP of 2.8% per year during that period (PDNA, 2008-2011). Ultimately, this drought caused huge economic losses in Kenya across all sectors (GOK, 2012). Other droughts that had significant impact in livelihoods and economy in general include the 1999- 2000 La Nina drought that led to power rationing in Kenya leading to a loss of approximately US $20 million to Kenya Power and Lightening Company (KPLC) and serious disruption of economic activities. The national gross domestic product (GDP) contracted by about 0.3% as the aftermath of the drought (Huho, Julius, Mashara, and Musyimi, 2016).

2.3 Impacts of Climate Change Related Disasters

Impacts of CCRDs range from socio-economic, environmental, physical and ecological. In 1997/1998, the El Niño-associated floods affected many parts of Kenya, causing destruction to property, loss of lives, famine and waterborne disease epidemics. With inadequate preparation for the El Niño floods, national resources were overstretched in the response phase. The El Niño-induced floods of 1997–1998 caused some US $151.4 million in public and private property damage. This Figure does not include the number of people who lost family members, savings, property and economic opportunities. More recently, floods in 2012 are estimated to have cost US$100 million (Kenya Disaster profile-PCG County note).

Otiende (2009) cited in Nyakundi *et al.,* (2010)) notes that the small and medium size floods that occur perennially in the Nyando District have an equally devastating cumulative effect with annual damages of over Kshs, 49 million and annual relief and rehabilitation of over Ksh 37million. Bodoque, Amérigo, Díez-Herrero, García, Cortés, Ballesteros-Cánovas, and Olcina (2016), reiterated the same point where they opined that flash floods exhibit rapidity, suddenness and high intensity in their onset and as such they pose a significant threat to human systems in the relatively small geographical areas affected.

Basic environmental impacts of floods are on the morphological changes along the river course. Basic environmental impacts of drought on the other hand are on the loss of soil moisture and declining volumes in water reservoirs. Among the intangible impacts listed are losses of human life, ill health due to waterborne diseases, increased hazards, vulnerability of survivors and out migration with reduced conflicts in the area. During floods, especially those related to El- Niño events, environmental diseases such as typhoid, amoeba, cholera, and bilharzia, normally associated with contaminated water and poor sanitation, reach epidemic levels in areas where water and sanitation facilities are inadequate or are in poor state (NCCRS, 2010). This was the case for Nyanza, Western, Coast, Eastern and North-Eastern Provinces, which recorded several cases of cholera outbreaks during the 1997/1998 El-Niño rains. In addition, warmer waters provide conditions conducive for the survival of the amoeba protozoan. Opondo, (2013) reported that floods 'severely' affected livelihood activities, particularly crop production, as reported by 339 respondents (85%), food prices (69%), housing/property (44%), and livestock

(42%) in a survey carried out on impacts of floods in Budalangi District of Western Kenya. Since these were also the sources of income, most households in this study reported depressed incomes. The transport sector has not been spared the ravages of floods. Pit latrines in some schools had either collapsed or were not usable due to the floodwaters. This rendered communities minus toilets and open defecation became the practice, further aggravating the situation on poor sanitation, hence higher numbers of people affected by waterborne diseases.

In 2007, the brief but also intense rains caused the collapse of the Kainuk Bridge in Rift Valley Province cutting off the supply of crucial goods including foodstuff to the agriculturally unproductive Turkana and Samburu Districts. Kenya's already dilapidated railway network is likely to be further damaged by floods and extreme heat, which the country is expected to experience as the climate changes in the tropics. The high temperatures are likely to cause warping of the rail track thereby exacerbating the chances of derailment of trains while flooding will wash away bridges. Such was the case in 1993 when 114 people perished in a train that plunged into a river after floods washed away a bridge at Ngai Ndethya National Reserve near Voi in Coast Province (NCCRS, 2010).

Droughts are particularly damaging in Kenya, and when followed by heavy rains can lead to flood events. Droughts also have major economic and social implications, especially in the developing world where national GDPs rely heavily on agricultural production (GoK, 2012). Drought has economic impacts such as the severe drought of 2008 – 2011 had overall effect of about Ksh 968.6 billion. (Ksh 64.4 billion due to the destruction of physical and durable assets and Ksh 904.1 billion losses in the flows of the economy across all sectors) (GoK, 2012). Other droughts that had significant impact in livelihoods and economy in general include the 1999-2000 La Nina drought that led to power rationing in Kenya leading to a loss of approximately

US $20 million to Kenya Power and lighting Company (KPLC) and serious disruption of economic activities.

The national gross domestic product (GDP) also contracted by about 0.3% as a result of the aftermath of the drought (Huho, Mashara and Musyimi, 2016). Drought can also result in agricultural losses, reduction in water quality and availability and is a major driver of food insecurity (Ochola, 2009). Failure of the long rains (March–May) in 2004 caused a severe drought, which led to 70% loss of livestock in some pastoral communities (Huho *et al.*, 2016). Information on impacts of CCRDs, specifically floods and drought, on soils and water sources in Nyando is lacking and this study hopes to document this. Of interest is the fact that these impacts if not addressed adequately could compromise the productivity and health of the productive assets with subsequent impacts on the users. The degree of impact depends on the ways in which the natural triggering event interacts with particular ecosystems and with the specific characteristics of the society affected, including its level of economic development; the types of livelihoods of its members; education levels; and other factors that generally determine both how resilient the affected population is as well as what resources are available for adaptation (Malone, 2009).

Impacts of Floods on Soils

Soil health refers to the ecological equilibrium and the functionality of a soil and its capacity to maintain a well-balanced ecosystem with high biodiversity above and below surface, and productivity (Cardoso, Rafael, Daniel, Cristiane, Paul, Alessandra, André, Jamil and Marco, 2013). Floods affect soils in many ways creating significant challenges for agricultural lands. Environmental impacts of floods can be wide-ranging from the dispersal of low-level household wastes into the fluvial system to contamination of community water supplies and wildlife habitats with toxic substances, deposition of debris and carrying away of top soils.

Floods may lead to intense soil erosion with subsequent decreased soil fertility as reported by Thorlakson, (2011) reported in Lower Nyando due to the 2010 floods.

Reduced vegetation cover on land exacerbated the erosion. Despite this the people still rated soil erosion as the least significant constraint to farm productivity after unpredictable weather, access to capital, access to implements, access to inputs, family illness, labour, soil fertility, pests and diseases probably due to the fact that the negative effects manifest slowly over time (Thorlakson, 2011). In the River Nyando Basin, accelerated soil erosion and nutrient runoff has led to a rapid rise in nutrient levels in Lake Victoria (Kung'u and Namirembe, 2012). Soil erosion causes reduced yields because of nutrient loss, reduced water retention and infiltration, reduced soil organic matter and reduced organic carbon (Ubuoh, Uka and Egbe, 2016). In Nyando Sub-county the soil organic matter content ranges from low (1.16% Total Organic Carbon (TOC)) to adequate (3.66% TOC) (NAAIAP, 2014). The low soil organic matter content results in low water holding capacity and may lead to soil erosion by runoff water during the rains. This can also impact negatively on the microbial activities in the soil. These soils were also found to be limited in two nutrients namely nitrogen (57% of farms) and phosphorus (33% of farms) which are below adequate level. When soils are degraded, invasive species and weeds take advantage and get established at the expense of the endemic/local vegetation cover. Floods may cause water logging in soils with high clay content due to slow percolation of water (Bloemertz, 2014). Soil flooding can cause hypoxia leading to a reduction in the soil nutrient content released.

Floods can also render farms uncultivable for the time it is submerged and even deposit sediments on farms that will make cultivation expensive and difficult for some time. Floods therefore have a large potential of reducing food production. Nutrient loss was documented as one of the indicators of decline in agriculture in Nyando and in extreme circumstances plants can be washed away or flattened by the water and debris. As a result of these effects after floods, farmers are challenged by yield losses and devastation of arable land. Subsequently, producers need to plan for the slow recovery of their arable soils (Armah, Yawson, Genesis, Justice and Ernest, 2010).

Impacts of Floods on Water Sources

Floods lead to soil erosion and may cause siltation of wetlands. Siltation may in turn cause de-nitrification of the soil by bacteria, due to less oxygen being present in the soil. Masese (2012) identifies siltation due to soils deposited by floods as a threat to Nyando Wetlands. Poor farming practices and deforestation in the upper Nyando catchment area has led to heavy siltation in the Rivers Nyando and Awach and the silt is eventually deposited in the wetlands. This leads to loss of wetland areas with subsequent loss of wetland values and services. On the other hand, floods are a blessing in disguise to the conservation of wetlands since everybody is forcefully thrown out of the wetlands giving the wetlands a chance to recover from anthropogenic stress during the dry season. However, flooding paralyzes the community livelihoods activities and their investments go down the drain (Raburu *et al.,* 2012).

The environment suffers when floods happen. Chemicals and other hazardous substances end up in the water and eventually contaminate the water bodies that floods drain into as highlighted by Sun, Daizhi, Wei, Yun, Lili, Can, Ping, Hongjuan, and Qiang (2012). The most serious consequence of flooding according to Sun *et al.,* (2012) is large-scale contamination of drinking water (surface water, groundwater, and distribution systems). Drinking water can be contaminated with microorganisms such as bacteria, sewage, heating oil, agricultural or industrial waste, chemicals, and other substances that can cause serious illnesses (Murshed, Aslam, Lewis, Chow, Wang, Drikas and van Leeuwen (2014); Yard, Murphy, Schneeberger, Narayanan, Hoo, Freeman, Lewis and Hill (2014); Chaturongkasumrit, Techaruvichit, Takahashi, Kimura, Keeratipibul, (2013). Nyakundi *et al.,* (2010) established that wells/boreholes followed by rivers/streams are the major sources of water both for drinking and domestic use in Nyando District. At the same time, almost all households reportedly had shallow and temporary pit latrines that easily fill up during the rainy season and this could be the most probable way that diarrheal diseases spread fast since the faeces could easily find their way into water sources such as wells, unprotected springs and rivers. In the case of Nyando Sub-county bacterial contamination from faeces, agricultural and industrial waste (Sugar factories and rice mills) and chemicals from agricultural runoff could be potential sources of contaminants of water bodies. However their study was concerned with socio-economic impacts and gave little focus on impacts to water sources and soils and how the community recovers from this.

Impacts of Drought on Soils

Drought may result in reduction of soil quality. Soil moisture essential for microbial activities, is reduced in drought conditions and consequently there is minimized organic activity and continued dry spell which kills soil organisms (Thorlakson, 2011). The end result is dry and cracked soil which makes it easier for desertification to set in. Drought also makes it unsuitable for plants and vegetation cover to survive leading to bare soils susceptible to both wind and water erosion. An increase in wind intensity exacerbates the impacts of drought causing bowl dust (Bryan, Ringler, Okoba, Roncoli, Silvestri and Herrero, 2013). Wind erosion subsequently causes land degradation, burying and killing vegetation where it settles and in addition to this, the dust may portend negative health effects to the people in the area. Soil salinity levels increase during extended drought periods because less water is available to leach salts already present in the soil. This can lead to an abundance of concentrated salt. When soil salinity levels are high, by osmosis water is pulled from the plant roots back into the soil, depriving the plant of any available moisture and causing potential loss in growth and productivity.

The Nyando Basin suffers not only from flooding; it is also subjected to periods of drought. December to February would typically be the area's dry period, but in 2011, that spell extended from November all the way to April. Communities could see clearly that there had been a change in the rainfall pattern, which at times of drought kills vegetation and increases the distances they have to travel to allow their cattle to drink (Masese *et al.*, 2016). Studies in the basin showed that communities experienced difficulties striking water when digging wells during the dry spells showing that the water table had been affected. Recha, Gachene and Lieven (2017) projections (2030-2050) indicate that there will be an increase in soil moisture stress in Nyando due to high evaporation as a result of increase in daytime temperatures. This is likely to exacerbate the impacts of drought in Nyando River Basin.

Impacts of Drought on Water Sources

Water sources in Nyando include boreholes, rivers and streams, rural ponds (*yawo*), rainwater and piped water (LVBC, 2011). Wells/boreholes followed by rivers/streams were the major sources of water both for drinking and domestic use in Nyando District. Access and quality issues have remained a thorn in the flesh for residents of Nyando District especially during the long spells of drought. During drought the water table is lowered and less water is available for domestic use from the wells. According to key informants in the area, the rivers also dry up and in some instances, dry riverbeds turn into roads passable by even motor vehicles (Nyakundi *et al.*, 2010)

Wetlands serve crucial ecological and provision services but they are also adversely affected by drought. Apart from filtrating and cleaning the water entering the lake, the Nyando wetlands close to the lake further serve multiple important purposes: They are a source of papyrus and reeds and also a grazing refuge during the dry period (Bloemertz, 2014). Consequently, during drought, all livestock of the riparian communities are driven to the wetland for grazing (Masese, 2012), there is reclamation of wetlands for agricultural purposes, overharvesting of wetlands plants for construction of houses and making fishing gears, destruction of fish spawning and breeding grounds through destructive fishing techniques and burning of wetlands for various purposes amongst others. All these activities not only degrade the wetland, but also increase the number of resource use conflicts among the stakeholders (Obiero, Raburu, Okeyo-Owuor and Raburu E., 2012). Drought also increases fire incidents in the wetlands. When large herds of cattle are driven into the wetlands, they cause overgrazing. This leads to severe environmental degradation such as destruction of wetlands plants and soil erosion (Masese, 2012). All these factors combined may lead to modification of wetlands hydrology, plant succession and possibly the microclimate of the area (Obiero *et al.*, 2012).

2.4 Concept Resilience

Olsson, Barbosa, Bhadwal, Cowie, Flores-Renteria, Hermans,….et al., (2019), defines resilience as the capacity of interconnected social, economic and ecological systems such as farming systems, to absorb disturbance (for example drought, conflict, market collapse), and respond or reorganize, to maintain their essential function, identity and structure. Resilience in the context of socio-ecological systems (SES) is the capacity of a SES to continually change and adapt and yet remain within critical thresholds (Folke, Carpenter, Walker, Scheffer, Chapin and Rockström, 2010). Inspired by a systemic conceptualization of resilience and especially of complex adaptive systems, resilience has moved from the core idea of 'resisting and recovering' (Parsons *et al.*, 2016) to 'adapting'; and from 'stability' to 'change' (Kuruppu and

Willie, 2014). From these many definitions, it is apparent that resilience is a very dynamic term, which can be operationalized by various disciplines. These many definitions notwithstanding, researchers using the same fundamental concepts are used to inform the management of human-environment systems, to maintain or improve resource base and sustain livelihoods (Olsson *et al.*, 2019). Daniel (2011) in his efforts to formalize the theory of resilience, ascertains that resilience has three salient characteristics:

i) Resilience is a quality of a system

ii) Resilience is perceived when taken in reference to an external factor.

iii) Resilience is dependent on a coping strategy.

Since the application of resilience to ecological studies of 1973, works from various authors have shown the linkage of resilience to explain socio-ecological systems (Aldunce *et al.*, 2015; Parsons *et al.*, 2016; Ranjan and Abenayake, 2014) in which communities respond to disturbances or disasters within a natural environment. Broadly, resilience when applied to human systems is best conceptualized as a capacity and process rather than as an outcome, and closer to the evolutionary and socio-ecological resilience perspectives than to engineering resilience or to any equilibristic theory (Imperiale and Vanclay, 2016).

Many studies have considered different dimensions of community resilience to disasters in their models such as physical/technical (Joerin, Rajib, Yukiko and Ramasamy (2012), Social (Khalili, Michael, and Philip (2015); Kusumastuti, Viverita, Zaafri, Lenny and Dwi (2014), Economic (Joerin *et al.*, 2012; Khalili *et al.*, 2015), political, infrastructure (Kusumastuti *et al.*, 2014), community (Kusumastuti *et al.*, 2014) and institutional (Khalili *et al.*, 2015). Kotzee and Reyes (2016) included the ecological dimension as a measure of resilience. The ecological dimension has not been studied much in the resilience frameworks, yet ecological factors play a critical role in regulation and moderation of processes that may enhance resilience of communities (Sharifi, 2016). Mayunga (2007) emphasizes that resilience is a function of the five capitals namely: social, economic, human, natural and physical. Keating, Karen, Colin, David and Meinrad (2016) agreed with the capital based-approach. They defined disaster resilience as the ability of a system, community or society to pursue its social, ecological and economic development and growth objectives, while managing its disaster risk over time in a mutually reinforcing way. They agreed that community flood resilience is about the combination of capacities across different dimensions. Mayunga (2007) posits that in the context of disaster resilience, natural resources such as wetland and vegetation cover play an important role in protecting coastal areas from weather-related hazards such as hurricanes and floods.

Natural capital can be measured through water quality, air quality, soil quality, wetland, forests, and national or local parks. Ranjan and Abenayake (2014) emphasized the importance of community perceptions in the initiatives geared towards making resilient communities. They noted that although several initiatives have been implemented to build disaster resilient communities questions abound as to whether those initiatives were shaped with adequate accounts of the expectations of people on disaster resilience. Aldunce *et al.*, (2015) in studying how people construct resilience, identified seven core discourse categories: preparedness/response, self-reliance, experiential learning, surrounding environment, information, education, communication, governance, co-management and social capital. Ranjan and Abenayake (2014) ranked in decreasing order a wide range of attributes that a community perceives as the factors contributing to their resilience as follows: experiential knowledge, level of income, communication facilities, geographic location, and Social Networks. Speranza, Ursand Stephan (2014) constructed an indicator framework for assessing livelihood resilience using three major attributes namely buffer capacity, self-organization and capacity for learning which were further decomposed into various proxy indicators namely: ‘‘capacity’’, ‘‘persistence’’ and ‘‘rate of recovery’’. According to them a livelihood is thus resilient if it can maintain its key functions (food, income, insurance, poverty reduction, amongst others) and absorb the impacts of disturbances without causing major declines in production and wellbeing. Vugrin, Warren, Ehlenand Camphouse (2010), conceptualizes system resilience as being characterized by the absorptive, adaptive, and restorative capacity indicating internal robustness, self-organization for recovery, and easy recovery respectively. They used these attributes to construct a Recovery Cost Index (RCI) to measure the levels of resilience of communities.

Sharifi (2016) analyzed the various tool kits used for measuring resilience and concludes that most Community Resilience Assessment (CRA) tools are broad in scope and address multiple dimensions of resilience. Selected tools rely on both existing secondary data and primary data collection for assessing resilience. Since resilience is a normative concept and ‘‘a scientific construct that has to be inferred and cannot be directly observed or measured’’ (Obrist *et al.*, 2010, cited in Speranza *et al.,* 2014), proxies and indicators can be used to evaluate resilience and to measure the contributions of a practice to resilience. Yu, Sung-Wook, Chang-Whan, Hyunuk, and Jin-Man (2015), successfully used recovery costs as a proxy to assess resilience to floods disasters in Korea. The rationale was that recovery costs are indicative of the restorative capacity of affected regions. The recovery cost showed a high correlation with loses incurred and could therefore be used to assess resilience. Parsons *et al.*, (2016), after a comprehensive analysis of the definitions and content of resilience by different scholars summarizes assessment of disaster resilience as a process that requires consideration of the capacities (the resources) within a system that influence absorbing and persisting in the presence of natural hazards and which enable learning, adjustment and transformation.

In this study the socio-ecological perspective is adopted and resilience will be assessed using coping capacities and success of recovery (depicting learning and adaptability) from impacts of CCRDs. Lindsay and Jones (2015) argued out another dimension of resilience namely subjective resilience and went on to demonstrate that resilience stems from the premise that people have a good understanding of the factors that contribute to their ability to anticipate, buffer and adapt to disturbance and change. Subjective household resilience, therefore, relates to an individual's cognitive and affective self-evaluation of their household's capabilities and capacities in responding to risk (Lindsay and Jones, 2015). If that is the case, a measure of the efficacy of the coping mechanisms employed can indirectly point to the resilience of households. The rationale here is that all the subjective factors informed the choice of the coping strategy. The indicators of resilience in this study are the coping mechanisms and the success of the coping mechanisms referred to here as recovery.

2.5 Coping as an Attribute of Resilience

IPPC (2012) refers to coping as the use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning in the short to medium term. From this definition, it is apparent that coping is instrumental in the survival of adverse conditions and that coping is a driver of resilience. (Shikla, Skea, Buendia, Masson-Delmotte, Portener, Roberts, Zhai, Slade, Connors *et al.*, 2019). Coping capacity therefore assesses the potential for disaster resilience within the system of interest, rather than the actual realization of disaster resilience in relation to a particular natural hazard event (Parsons *et al.*, 2016). Adaptive capacity differs from coping capacity in that adaptive capacity focuses on the potential for the facilitation of adaptation by governance, institutional, management and social arrangements and processes (Birkmann, Cardona, Carreño, Barbat, Pelling, Scheiderbauer, Kienberger, Keiler, Alexander, Zeil and Welle, 2013) whereas coping capacity focuses on the capacities of communities to anticipate and respond to hazards.

This study seeks to establish short-term correctives referred to here as coping mechanisms whose incremental outcome may transform into long-term resilience of households to the impacts of CCRDs on the environment (soils and water sources).

Coping With the Impacts of CCRDs on Environment

Impacts of CCRDs on the environment as operationalized in this study refer to effects of floods and drought on soils and water sources. Subsistence agriculture is the main livelihood of the community in lower Nyando River Basin ((Nyakundi *et al.*, 2010). Tarfasa, Balan, Taffeta, Woldeamanuel, Moges, Dianto, Black (2018), reckon that agriculture in highly erosion prone areas requires site specific and long lasting soil and water conservation measures. Even though much work has been done on coping with floods and drought in the study area little has been done to document the impact, coping and recovery with a view to establishing the resilience to impacts of CCRDs on the environment. This study seeks to establish short-term correctives referred to here as coping mechanisms whose incremental outcome may transform into long-term adaptations of households to the impacts of CCRDs on the environment (soils and water sources).

Coping With the Impacts of Floods on Soils

Changes in rainfall patterns will tend to increase erosion of vulnerable soils and increase the risk of flooding. Soil organic matter is an important soil stabilizer. It keeps the soil structure in shape physically and via its positive influence on soil organisms, like earthworms allowing rainfall to percolate rather than to become surface run off. The more structure and organic matter, the more we can rely on the water retention capacities of soil. Cover crops help improve soil health by reducing compaction, increasing water filtration and retention and improving soil organic matter (White, 2015). Healthy soil is less susceptible to impacts from extreme weather events and better able to recover in addition to conferring financial stability to farmers since they would be better placed to withstand floods and drought and subsequently lose fewer crops, livestock, equipment and facilities (White, 2015). Cover cropping is the practice of planting a second, un-harvested crop in coordination with the cash crop to prevent wind and water erosion, reduce nutrient loss and leaching and improve soil health and quality (White, 2015).

Poor harvests have been correlated with not only drought, but also poor soils since soil fertility influences crop production. Oluoko-odingo (2006) examined the influence of unfavorable weather on household food security in Nyando District and prioritized farm size, family health and age of household head as principal components, determining the improvement of household food security and reduction of household poverty. Missing in that study and that of others is the link between the health of the ecosystems, which provide the natural capital, and food security. Another glaring gap in the studies conducted in Nyando Sub-county relates to remediation/rehabilitation efforts of soils after floods and how successful the interventions are, if any.

Coping With the Impacts of Floods on Water Sources

While acknowledging that national and global drivers play a significant part in flood resilience, Keating *et al.*, (2016) emphasizes that it is at the community level where flood impacts are felt most viscerally and where much action on flood resilience needs to be taken. Such communities therefore ought to be the focus of many flood and development activities aimed at building resilience. Communities in Nyando river basin have been experiencing frequent floods and have learnt how to minimize the impacts through three types of adaptation strategies: technological/structural, economic and social organizational mechanisms which they employed during pre-flooding, flooding and post-flooding period (Masese *et al.,* 2016). Furthermore, different socio-economic groups implement different adaptation measures because of their differential access to livelihood assets such that households with lower income and less access to productive natural assets face higher exposure to risk of flooding (Masese *et al.,* 2016), and any other natural hazard. The challenge with such an approach is that with each flooding cycle, the limited resources are committed to the short-term adaptation strategies and little if any is left to improve the living standards rendering the communities poorer each time. These individualist activities fall short of building resilience in these communities since the meager resources are always committed to short term coping strategies whenever flooding occurs and hence compromising the capacity of households to improve their living standards. Masese *et al.,* (2016) also found out that the strategies adopted by communities in flood prone areas of Nyando Basin were short term and could lead to unsustainable present and future livelihoods for residents of flood-prone areas. Opondo (2013) also noted the same trend in Budalangi, where the coping strategies employed by flood prone communities in Budalangi district of western Kenya were not sustainable since they were potentially counter-erosive in nature destroying household assets base and ultimately leading to increased vulnerability to future floods. Such strategies included sale of property, extra income-generating activities, modified food consumption, and reduced expenditure on household requirements, migration and temporary relocation. The respondents in Budalangi felt that laws can help to protect people who fail to see or recognize flood hazards (Masese *et al.,* 2016). From their sentiments it is apparent that local communities know what actions are sustainable. Their only shortcoming is the lack of power and sometimes resources to implement them. Such powers may be vested in institutions with the capacity to enact and enforce Laws and regulations, which ensure public safety and also to build capacity in locals on how to tackle climate related disasters. Nyakundi *et al.,* (2010), observes that at present, most of the efforts of those concerned with disaster management in the Nyando District were focused either on emergency health preparedness or post-emergency relief.

Little has been done to embed sustainable practices into the communities with a view to building resilience. She recommended a shift in the national and international mindset, from reaction and charity to anticipation and pre-emption. She further notes that the community should be encouraged to understand the importance of global climate and improve their indigenous coping strategies since climate change is likely to exacerbate the impacts of floods and increase the vulnerability of communities. Mainstreaming flood disaster preparedness in the local plans is therefore one way of preparing to cope with disasters and in so doing build resilience in the local communities. Enhancing the adaptive capacity of communities is the other way of assuring resilience to CCRDs**.** Planned adaptation interventions therefore need to acknowledge the people's ability to plan, their right to choose, and the right to be able to make an informed choice (Ranjan and Abenayake, 2014). The current situation and evidence from the study indicates that coping measures require policy intervention to enable households to develop the capacity to utilize resources available locally to cope with flood impacts more sustainably (Masese *et al.*, 2016).

Nyando Sub-county also suffers from acute problem of clean piped water, which further diminishes during the flood season. Issues of water contamination during floods therefore pose great danger to human health. Determining ways of protecting the water sources and assuring clean water access in times of floods is therefore paramount. A post flood needs assessment conducted in Nyando District in 2013 revealed that hand pumps installed and shallow wells, which are the common source of drinking water, were submerged in the floodwater and others were not working yet after the flood waters receded, these water sources were back in use despite not having been treated. The report recommended household water treatment and disinfection of all water sources. The main sources of drinking water are unimproved and highly contaminated. Consequently, there has been a high incidence of waterborne disease in Lower Nyakach.

Amongst the main challenges facing the Nyando Wetlands is the limited awareness of the ecological and economic importance of wetlands as the precursor of negative tendencies that put well-being of wetlands at risk yet their livelihoods depend entirely on the sustenance of these values (Masese *et al.,* 2016 in Raburu *et al.,* 2012). Practices by people that include harvesting wetlands products for use such as papyrus making, brick making and cultivation point indicate that the communities benefit financially from wetlands. The same cannot be said of the ecological benefits which are intangible yet very crucial for sustainable livelihoods. In the absence of economic benefits (which may be eroded by CCRDs), the will to protect wetlands may be lacking. These points to the need to embrace ecological sustainability of wetlands and the need to cushion them from the impacts of CCRDs like floods and drought. The information gap in Nyando Sub-county is how households protect their water sources and how successful the interventions to protect water sources after floods are. This forms the basis of this study.

Coping With the Impacts of Drought on Soils

An increase in vulnerability to drought hazard may result from an increased frequency and severity of drought, increased societal vulnerability, or a combination of the two (Bekele, Kindie, Menale, Tsedeke, Prasanna and Abebe, 2014). Oluoko-Odingo (2006) observed that weather fluctuations, inadequate food reserves, and poor management of the existing resources, make food security attainment impossible even within the medium potential areas like Nyando district. The resources in reference here include not only human resource but also water and farmlands. The common practice with Kenyan government is to provide relief food in times of disasters such as floods and drought that lead to crop failure (Nyakundi *et al.*, 2010). However Wilhite, Donald, Mannava and Roger (2014) cautions that the provision of drought relief or assistance to those most affected increases vulnerability to future drought episodes by reducing self-reliance and increasing dependence on government and donor organizations and recommends that emergency relief be provided in such a manner that it provides a safety net for those elements of society that are most vulnerable while promoting self-reliance and the principles of a national drought policy based on the concept of risk reduction. In order to minimize the impact of droughts on household food security, drought resistant crops should be encouraged (Oluoko-Odingo, 2006). Because of the creeping nature of drought, its effects accumulate slowly over a substantial period of time (Wilhite *et al.*, 2014) making planning a critical ingredient when dealing with drought. It is in this context, that the study seeks to establish how households in Kisumu County manage their soils in order to assure its structure and function in the face of CCR drought.

Coping With the Impacts of Drought on Water Sources

Today more than ever before, droughts are predictable phenomena. Technological advances have made weather forecasting an increasingly exact science. Droughts have a slow-onset nature and are predictable and hence better management of their impact on communities is possible and will eliminate their worst effects (Country Program Paper, 2012). Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderate potential damages, and cope with adverse consequences (IPCC, 2012). In a study conducted in four ecological zones in Ghana the residents engaged in non-climate sensitive occupation, migration to urban areas, expansion of farm sizes and crop diversification in decreasing order of preference as ways of coping or adapting to climate induced impacts (Dumenu and Obeng, 2016).

Masese *et al.,* (2016) recommends that removing pressure from wetlands and improving their resilience is the most effective method of coping with the adverse effects of climate change. The land management practices in the upper catchments may also contribute to the enhancement of surface water run-off and flooding and an unplanned human occupation in the lowland can also enhance the damages due to flooding. The information gap is how the households are engaged in improving the resilience of wetlands in the face of drought. Of importance would be information on how the people contribute to their vulnerability to drought either by engaging in counter erosive practices or by ignoring crucial interventions that would otherwise help their situation. An understanding of how communities in Nyando Sub-county perceive the impacts of drought on their water sources, how they prepare for such eventualities and how they recover from the impacts of drought could shed light on their levels of resilience.

2.6 Recovery as an Attribute of Resilience

Recovery is defined as "the act or process of returning to a normal state after a period of difficulty (Merriam-Webster). Nevertheless, most lay people think about disaster recovery as a return to normality. This may not be a return to the status before the event; in fact this may be undesirable if the place was excessively vulnerable, However too speedy a recovery may change the nature of the socio-economic system in ways that people do not want especially when external support is injected to facilitate restoration to normalcy and therefore it is important to consider economic utility and social well-being in recovery interventions (Platt *et al*., 2016).

Many factors may affect the recovery process such as wealth **(**Béné *et al.*, 2016). Opondo (2013) noted that even though wealthy households may also incur severe losses due to floods, they are able to recover quickly as opposed to the poor households who have no capital to facilitate their quick recovery rendering them less resilient. The levels of preparedness will also impacts the recovery process (Aldunce *et al.*, 2015). Recovery costs are important for assessing resilience to disasters as well, since they represent the restorative capacity of a system (Yu, Kim, Oh, Hyunuk and Kim, 2015). Vugrin *et al.*, (2010) reiterated that recovery is also impacted on by cost. The levels of success (quality) of recovery can also denote resilience (Platt, Brown, and Hughes, 2016). In this study recovery will be operationalized using a set of questions targeting the activities undertaken to restore soil and water sources following impacts of CCRDs (floods and drought) and the degree of success of the interventions adopted. The degree of success of recovery would be commensurate with how much learning and adaptation has taken place when dealing with CCRDs, which is reflected in the outcomes of restoration efforts UNISDR (2012) operationalized a global resilient cities Campaign using a TEN ESSENTIALS Framework and Approach in exploring resilience of three pilot cities in Africa namely Moshi, Kisumu and Narok. The TEN ESSENTIALS recognizes recovery and rebuilding communities as essentials of resilience. Platt *et al.*, (2016) demonstrated that it is possible to measure the speed of recovery using various direct and indirect methods, including remote sensing, social audit and published data. Remote sensing, in particular provides a useful method of extracting detailed statistics on changes, and offers benefits in terms of accuracy and reliability of measurement. In contrast, traditional social audit tools of interview and survey are relatively cheap and give fairly reliable results, but lack accuracy and detail.

2.6 Socioeconomic Factors and Coping With Impacts of Climate Change Related Disasters

Most studies in the field of disaster studies argue that disasters must be understood in relation to social change (Imperiale and Vanclay, 2016). Social factors can be described as those factors that relate to the individual by virtue of gender, location, livelihood and day-to-day interactions with his/her environment. Social characteristics have been found to influence to a great extent

(Béné *et al.*, 2016) the social behavior when disasters strike. Whereas socioeconomic variables, such as income, education, and age, will not influence the occurrence of climate extremes, they can impact the way populations are able to prepare for, withstand, and recover from the impacts (IPCC, 2012a). Existing socio-economic conditions vary from one person to the other and therefore a disaster can lead to different outcomes even for demographically similar communities.

Gender is not merely a variable that assesses the differences between men and women in the wake of disasters. It is also how living conditions, demographic and economic attributes, behaviors and beliefs reflect gender power relations in this context (Cvetkovic´, Giulia, Adem, Tarolli, and Slavoljub, 2018). In order to test the central hypothesis of which gender is a predicting variable in all the stages of the disaster cycle in Serbia, Cvetkovic´ *et al.*, (2018) used a multivariate regression analysis in identifying the extent to which seven independent variables were associated with five socio-economic variables: gender, age, education, marital status, and income. The results yielded gender ($\beta = -0.143$), as the most important predictor of individual preparedness and it explained 14.3% of variance. The most important predictor of household preparedness was also gender ($\beta = -0.049$) explaining the 4.9% of variance ($R^2 = 0.009$, Adj. $R^2 = 0.007$, $F = 4.36$, $t = 51.25$. $p = 0.000$). On the other hand, a multivariate regression with flood risk map knowledge information showed that the most important predictor is educational level ($\beta = -0.078$) explaining the 7.8% of the variance.

Béné *et al.*, (2016) while investigating whether resilience is socially constructed identified a knowledge gap regarding the nature and role of different forms of social capital and the conditions under which these can contribute effectively/positively to building people's resilience at different levels. This followed their findings that the factors that influence certain responses of households are not necessarily the same factors that influence the success of recovery, citing wealth as an example. Wealth did not influence people's choices of responses in relation to a fishery crisis. Both the wealthy and not so wealthy resorted to increased fishing effort, a maladaptation in this case. However they established that wealth is an important factor in the recovery process of households affected by shocks and stressors because wealth confers households indirect consequences of improved income/assets such as more travel and exposure to ideas and information, better social status and a more influential voice in the community, or even more self-confidence.

Twyman, Green, Bernier, Kristjanson, Russo, Tall, Ampaire, Nyasimi, Mango, McKune, Mwongera, and Ndourba (2014) established that gender and religion shape access to different sources of information and therefore affect men and women differently in their abilities to adapt to climate change while investigating the role that gender plays in adaptation actions in Africa. Their findings also suggested that climate and agricultural information is likely to result in uptake of new agricultural practices for adaptation. This could be explained by the fact that women are more engaged in on-farm agricultural practices as opposed to men (Michura, 2016).

2.7 Socio-economic Factors and Recovery From Impacts of Climate Change Related Disasters

All disasters include components of social choices, social constraints and societal actions or inactions (Sauerborn and Ebi, 2012). According to IPCC (2012), socioeconomic variables, such as income, education, and age, will not influence the occurrence of climate extremes but they can impact the way populations are able to prepare for, withstand, and recover from the impacts. Imperial and Vanclay, (2016) established that people in resilient communities share resources and put in place their own knowledge and capacities to collectively cope with change. They also share strategies and stories (aftershock communication) that strengthen their sense of social responsibility, their sense of public duty, their sense of place and the extent of their participation (aftershock engagement). Subsequently, solidaristic behaviour, cooperation, mutual aid, caring and sharing emerge, lead to the creation of a wonderful atmosphere of purposefulness, candor and joyfulness, which helps in strengthening people's sense of community, social cohesion and social capital. Their study focused on the understanding of social processes and the normative and ethical factors that enable the resilience that is embedded within local communities to flourish. Little mention was made of the ingredients that fuel these social processes.

The fact that people are first individualist precedes socialism (Masese *et al.,* 2016). In the natural construct of human behavior, individual dispositions in terms of age, level of education, assets owned and sex interacting in concert with the natural environment underpins recovery. Opondo (2013) established that gender manifests in coping with floods in Budalangi District of Western Kenya, due to the distinct roles male and women play. Men's roles after floods included supporting their families, rebuilding houses, replacing lost or damaged property, feeding livestock, and working on dykes. Women on the other hand, concentrated on feeding their families, caring for children and domestic chores. It is apparent that immediately after floods, little attention is given to the soils and water sources but people concentrate on the primary survival drives. The economic status of households has been found to determine the coping mechanisms and adaptations. Bryan *et al.,* (2013) found out that the choices of coping mechanisms are sometimes limited by the households' lack of financial resources to invest in new, more efficient mechanisms. A gap exists on the influence of social factors on coping and recovery from impacts of CCRDs on the environment.

2.8 Policy, Legislative and Institutional Frameworks on Climate Change/Disaster Resilience

In well-structured systems, policies, legislation and institutional frameworks guide most actions. These set important guidelines and principles for managing and controlling environmental resource use. The guidelines address issues of misuse, abuse or overuse of resources such as minerals, water, forests, land, soil, among others in addition to assisting in proper planning and economizing resources for the present and future use and for the wellbeing of all biodiversity. This section highlights some of the guiding principles espoused in global and local policies, legislation and institutions and which guide management and use of resources in the light of disasters and climate change.

2.8.1 Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA)

Hyogo framework has five priority areas, which prescribe institutional strengthening for DRR, identification and monitoring of risks, creating understanding and awareness through use of knowledge, innovation and education to build a culture of safety and resilience at all levels. It also addresses the need to engage proper practices like land use planning, environmental, social and economic measures to reduce underlying risk. Lastly it points out the need to strengthen disaster preparedness for effective response at all levels.

2.8.2 The Sendai Framework for Disaster Risk Reduction 2015-2030

The framework adopted at the Third UN World Conference in Sendai, Japan, on March 18, 2015 aims to guide the multi- hazard management of disaster risk in development at all levels as well as within and across all sectors. The framework applies to the risk of small-scale and large-scale, frequent and infrequent, sudden and slow-onset disasters caused by natural or anthropogenic hazards, as well as related environmental, technological and biological hazards and risks. It is premised on Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters. Priority 3 of the Sendai framework lays emphasis on investing in disaster risk reduction for resilience while pointing out that Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment. Such cost-effective measures can be drivers of innovation, growth and job creation.

2.8.3 Kenya Constitution 2010

The Kenyan constitution 2010 implies a right-based approach to the mainstreaming of climate change adaptations. The 2010 constitution of Kenya also recognizes the need for climate change adaptation through the bill of rights, which addresses issues of food, health, and water security. It also addresses the mainstreaming of climate change into development programs in Kenya. These include the National Climate change council, the Ministry of Environment, National Climate Change Focal Point, the National Drought management Authority (NDMA), Ministry of Development of Northern Kenya and other Arid and Semi-Arid lands (now defunct) and Ministry of planning and Devolution. Each of these ministries has a climate help desk.

2.8.4 Climate Change Act 2016

The Kenya government finally enacted into law the Climate Change Act 2016, which provides a regulatory framework for enhanced response to climate change: to provide for mechanism and measures to achieve low carbon climate development for sustainable development in Kenya. In addressing resilience, the Act shall be applied to all sectors of the economy by the national and county governments to mainstream and reinforce climate change disaster risk reduction into strategies and actions of public and private entities in addition to mainstreaming climate change responses into development planning, decision-making and implementation in all sectors of the economy. Opondo (2013) observes that National institutions are particularly important in providing policy frameworks within which local institutions operate as well as mobilizing capacity for interventions when extreme events occur. According to Warner and Zakelideen (2012) research shows that strong collaboration between national and local institutions can play a critical role in disaster preparedness and concludes that since adaptations are local, local institutions would play a critical role in building resilience to disasters. Kenya has not been left behind in this. The Directorate of Climate Change established under this Act is mandated to provide analytical support on climate change to the various sector ministries, agencies and county governments in addition to developing strategies and coordinating actions for building resilience to Climate Change and enhancing adaptive capacity amongst other roles. The Act provides for the formulation of a National Climate Change Action Plans, Strategies and policies.

2.8.5 Environmental Management and Coordination Act (EMCA 2015)

This is an Act of Parliament designed to provide for the establishment of an appropriate legal and institutional framework for the management of the environment and for matters connected therewith and incidental thereto. EMCA lays emphasis on the protection and conservation of the environment. Conservation of biological diversity both in-situ and ex-situ by identifying potential threats to biological diversity and devise measures to remove or arrest their effects. It also encourages the conservation of energy and planting of trees or woodlots by individual land users, institutions and by community groups. This includes prohibiting and controlling of alien species into natural habitats and integrating traditional knowledge for the conservation of biological diversity with mainstream scientific knowledge. The Minister may, by notice in the Gazette, declare a lake shore, wetland, coastal zone or river bank to be a protected area and impose such restrictions as is considered necessary, to protect the lake shore, wetland, coastal zone and riverbank from environmental degradation.

2.8.6 National Climate Change Response Strategy (NCCRS) 2010

The NCCRS (GOK, 2010) has been guiding policy decisions since its launch in 2010 through documented evidence of climate impacts on different economic sectors, and proposed adaptation and mitigation strategies to enhance the country's climate change response. This strategy document envisions a prosperous and climate resilient Kenya. It sets the basis for strengthening and focusing nationwide action towards assessing and monitoring climate change impacts on soils and water sources amongst other sectors. It goes further to highlight the need for identifying and encouraging adaptation and mitigation interventions for changing climate by ensuring commitment and engagement of all stakeholders while taking into account the vulnerable nature of the natural resources and society as a whole.

2.8.7 Kenya's National Climate Change Action Plan (NCCAP) 2013-2017

This medium term plan addresses climate change vulnerability by taking the adaption and mitigation efforts to the next step of implementation and spells out decisive actions that would guide the transition of the country towards a low carbon climate resilient development pathway. The strategy envisages that the priority investments would generally alter current practices or technology choices and result in a range of benefits that improve livelihoods and environment quality while contributing to economic performance. In Agriculture, the action plan singles out agro-forestry, conservation tillage, promotion of drought resistant crops, water harvesting, integrated soil fertility management, provision of climate change-related information and mainstreaming climate change into agricultural extension services as some of the interventions that have significant adaptation benefits to Climate Change. The strategy supports the mainstreaming of climate change in the vision 2030.On water, environment and sanitation, the action plan points out that increasing forest cover portends climate resilience and low carbon benefits. Priority adaptation actions identified targets improving water management (domestic water supply and sewage systems), enhanced irrigation and drainage in order to reduce the impacts of floods and drought on crop yields and livelihoods. It also affirms that irrigation-based agriculture reduces reliance of crop production on rainfall. Finally it recognizes the need for modernization of meteorological systems and an early warning and appropriate response to emerging drought that includes a well-maintained early warning system at actions that can improve climate resilience in the disaster preparedness program.

2.8.8 National Policy for Disaster Management in Kenya

The policy emphasizes preparedness on the part of the Government, communities and other stakeholders in Disaster Risk Reduction activities. In this regard, the policy aims at the establishment and strengthening of Disaster Management institutions, partnerships, networking and main streaming Disaster Risk Reduction in the development process so as to strengthen the resilience of vulnerable groups to cope with potential disasters. The Policy aims to increase and sustain resilience of vulnerable communities to hazards through diversification of their livelihoods and coping mechanisms. This entails a shift from the short-term relief responses to development. The Policy will go a long way in preserving life and minimizing suffering by providing sufficient and timely early warning information on potential hazards that may result to disasters. It will also aim at alleviating suffering by providing timely and appropriate response mechanisms for disaster victims.

2.8.9 National Drought Management Authority (NDMA)

The NDMA is an agency of the Government of Kenya established by the National Drought Management Authority (NDMA) Act 2016. It is mandated to focus on sound drought management by establishing and operating an effective early warning system, developing contingency plans and putting in place response system. Their role is to ensure that drought does not result in emergencies and that the impacts of climate change are mitigated through early warning of impending drought and issuing drought alerts.

2.9 Research Gaps Identified

The literature review has identified the impacts of CCRDS have always been there from time immemorial but no scientific research and documentation of the following:

i. Extent of the impact or magnitude on soils and water sources

ii. Sustainable coping methods of livelihood during the disasters

iii. Resilience of the peoples to all the CCRDs not been practically addressed by researchers.

2.10 Theoretical Framework

Several theories that have a bearing on the study were analyzed to expose their applicability, strengths and weaknesses to this study. One of them is the Complex Adaptive Systems Theory (CAS) theory. According to Rammel, Stagl, and Wilfing, (2007), Complex Adaptive Systems (CASs) are systems based on “complex behavior that emerges as a result of interactions among system components (or agents) and the environment. Through interacting with and learning from its environment, a complex adaptive system modifies its behavior to adapt to changes in its environment”. Coetzee, Dewald and Raju (2016) unpacked this concept and brought out the inherent similarities between the concept of resilience and CAS. They argued that communities are non-linear systems whose resilience to disasters cannot be explained by simple linear relationships models as captured in systems theory, yet they comprise a variety of capacities and non-linear interactions that could only be fully comprehended by considering the interaction of the parts that form overall resilience. They rationalize this theory by linking the CAS concepts such as non-linearity, aggregation, emergent behaviour, feedback loops and adaptation and context-based responses to adaptation and learning mechanisms that could contribute adaptive disaster resilience. They reason that resilience is not a product but a process, it is an open-systems process that is constantly changing due to the inflow and outflow of information (learning from past events) and building and breaking up of components (adding new resilience capacities/removing obsolete capacities) that constitute the resilience profile of a community. It is in this line of thinking that this study is suite for a complex systems approach, where several different impacts are addressed by several coping strategies whose successes also differ in magnitude but cumulatively they depict or yield the resilience continuum such as the ability of system to respond or bounce forward during CCRDs. The community under study is composed of complex context-specific variables (social, economic, political, physical, ecological), which Mayunga (2007) referred to as the 5 capitals that would determine resilience. The study however did not address all the five capitals but focused on the ecological and social capitals. The weakness in this theory is scenarios where all the five context-specific variables may not be applied in a single study hence diluting the complexity of the systems.

Another theory that has a bearing on this study is the Theory of Change (ToC). The origin of this theory may not be precisely traced but its highlights took root from the works of Weiss (1995), who popularized it as a way of describing the set of assumptions that explain both the mini-steps that lead to long term goal and the connections between programs activities and outcomes that occur at each step of the way. The focus is on mapping out the missing middle between what a program or change initiative does (its activities or interventions) and how these lead to desired goals. It creates an understanding of how change actually happens and therefore can lead to evaluation and planning of activities that would realize the desired outcome. This theory has been widely applied in various fields like in infrastructural projects like evaluating roads in East DRC, education for improving the quality of general education in Ethiopia (Vogeland Zoe, 2012), and medical (De Sliva, 2014) who proved that ToC can strengthen key stages of the Medical Research Councils' framework for complex interventions in the rehabilitation intervention for people with Schizophrenia in five low and middle-income countries (India, South Africa, Ethiopia, Uganda and Nepal). Its weaknesses however lie in the assumption that change takes a linear path yet the interaction between humans and their environments is a complex web. The impact pathway in this study conforms to the theory of change, which is analytical in nature, exploring the causes, impacts, factors that influence change at each level of intervention and the possible remedies to achieve the desired end (resilience) but it does not take care of the multiple pathways of interactions of the impacts and coping mechanisms.

The theory of the Tragedy of commons is an economic theory that describes a situation in a shared-resource system where individual users, acting independently according to their own self-interest, behave contrary to the common good of all users, by depleting or spoiling that resource through their collective action. Common resources include natural resources not owned by an individual e.g. oceans, fish stocks, atmosphere and communal lands. This theory is applicable in the natural resources management and planning (Anukowe, 2015). Depletion of common resources, deterioration of the state of common resources and degradation of the state of such resources is likely to follow the actions or inactions of the users especially in the absence or neglect of both formal and informal regulations. Solutions to the tragedy of commons would therefore be specific to the problem or the consequences of people's action or inaction on the natural resource. This theory is partly applicable in this study, especially when water sources are considered as common property but falls short of including land which is individually owned. The effects are also a consequence of another common phenomenon called climate change. In as much as individuals will try use and management of "their" soils and waters, the contiguous nature of these resources necessitates collective community action. The Resilience theory was subsequently selected based on its applicability to the scope of the study.

2.10.1 The Resilience Theory

The Resilience theory postulates that resiliency is determined by both risk and protective factors. Resilience theory addresses the strengths that people and systems demonstrate that enable them to rise above adversity (Van Breda, 2011). In medical studies, the risk factors were identified as those that pose a threat to caregiver resilience and mental health, such as stigma, isolation and occupational restrictions. The protective factors are factors that improve a caregiver's response to stress and strain, producing a positive outcome. Daniel (2011) emphasizes that resilience is always taken with reference to an external factor and which can be classified as a threat, disturbance or stress that has a damage-potential as its subclass, for instance, a society that has resilience to a hurricane event is not resilient to the hurricane event but rather it builds its resilience on the latent damage potential that the event possesses. The resilience approach to managing natural hazards has emerged more recently and contends that people have agency to prepare, adapt and transform given the presence of social cohesion, community involvement and trust (Usamah *et al.*, 2014).

The strength of the theory is that it recognizes that individuals and systems have the capacity (willpower, resources, assets, knowledge, attitudes and learning potential) to move on in times of adversity. However the theory is not devoid of weakness considering that Socio-Ecological Systems (SES) are complex adaptive systems that do not change in a predictable, linear, incremental fashion (Delgado-Serrano, Oteros-Rozas, Vanwildemeersch, Guerrero, London, and Escalante, 2015). Pisano (2012) reiterates that SES have the potential to exist in more than one kind of regime (sometimes referred to as "alternate stable states") in which their function, structure, and feedbacks are different. This implies that quantifying the strengths inherent in the ecological component of SES is difficult. Furthermore community resilience also lays so much emphasis on social support systems yet some communities may not be cohesive to the point of agreeing on a common approach to issues. People are becoming more and more individualistic with the move towards capitalism and further from socialism. In this study, the risk factors are the CCR hazards which lead to CCRDs namely floods and drought and the protective factors are the coping mechanisms and recovery efforts from impacts of CCRDs that the communities record. These two variables have the potential to foster resilience in the vulnerable communities.

2.11 Conceptual Framework

The conceptual framework was modeled based on the four theories discussed. In this study, the risk factors are the external factors herein implied as the threats or disturbance (floods and drought) and the protective factors are coping mechanisms which are either inherent in the communities or can be learned and actualized. These attributes are further decomposed into various quantifiable components. These protective factors ought to buffer the households and their livelihoods against the impacts of floods and drought (disturbances) on their natural capital (soils and water sources) and in so doing build resilience. A link between mitigating the risks through coping was explored. The study is cognizant of the complex nature of interactions in the environment between the hazards, people and the environment and hence it examined the relationships and the highlights the roles of each of these components in coping with environmental perturbations. Since the perturbations result in a shift of the normal conditions, it is inevitable that the human system must adjust to accommodate the changes and realize sustainable outcomes, hence the theory of change. Last but not least, the environment is a common resource and how it is utilized and managed by different individuals' impacts on its ability to provide goods and services to the entire community. This study focuses on how resilience of households is affected by impacts of CCRDs on the environment. The conceptual framework is displayed in Figure 1.

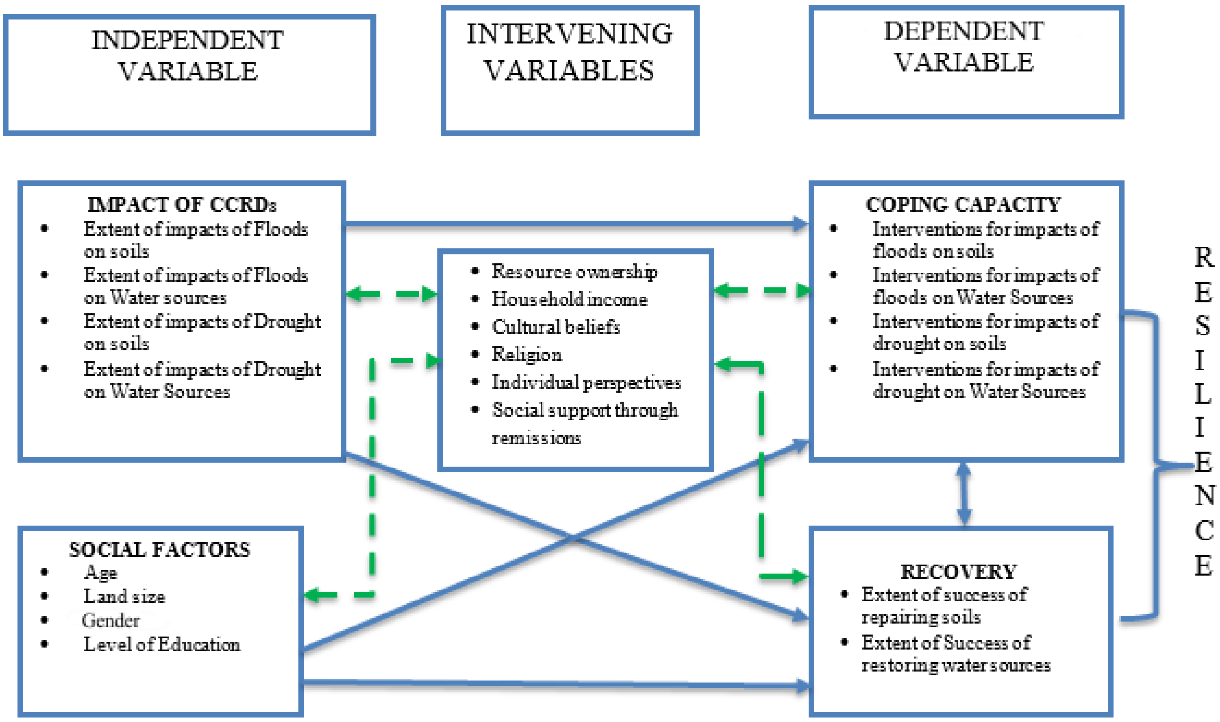

Figure 1: Conceptual Framework Model

2.11.1 Relationship Between the Variables

In this study, the independent variables are Impact and Social factors whereas the dependent variables are coping capacity and recovery. The variables relate as follows:

Impact and Coping Capacity

The impacts of CCRDs on soils and water sources have the potential to trigger some form of response in the affected households. The responses could be short-term interventions referred to as coping mechanisms or strategies if they are well structured or they could be long term strategies, which would amount to adaptations. Floods and droughts interfere with the structural and functional properties of soils and water sources. These would in turn compromise environmental services offered by the soils and water sources. The beneficiaries of the goods and services offered by soils and water sources would then engage diverse coping interventions in order to mitigate, withstand or escape the consequences. The success of the coping interventions engaged would in turn determine how resilient the households are to CCRDs. The greater the impact, the more intense or widespread the coping interventions the households should employ. On the flip side of this, higher magnitude impacts may raise the threshold/quality of coping capacities higher than the households can demonstrate rendering them less resilient.

Impact and Recovery

Most members of the community easily recover from events with a lower severity and the vice versa is also true that most members of the community do not easily recover from events with a higher severity. High impact of CCRDs may cause more damage or disturbance to the soils and water sources. This damage could be above the threshold of households’ ability to recover. On the other hand, low impact of CCRDs may lead to less damage or disturbance of the soils and water sources necessitating minor adjustments by households. Recovery in such situations would be easier and faster.

Socioeconomic Factors and Coping Mechanisms

Age as a factor is a double-edged sword as far as coping is concerned. On one side, as people age, they may be rendered less able to cope with disturbances especially if the coping strategies are pegged on energy and capacity to diversify and adopt new technology and ways of doing things. On the other hand, if the coping strategies to be involved are pegged on experience in doing the same thing, the aged are advantaged since they have done it over and over. Sometimes people get used to doing things the same way they are used to but the younger generation are flexible and quick to try out new interventions and change with the changing times.

The level of education would influence coping capacity especially where the intervention required to cope might be influenced by the comprehension capacity to appreciate and adopt new technology and skills. Education also broadens peoples' thinking capacity allowing for new ideas to take root.

Resource/Land tenure and size can influence the willingness of people to invest in conserving the land resources and implementing new interventions. If it is leased land, there are limits as to how far the land use change can be enacted. The size of land also influences the kind of interventions and the level of investment in a piece of land. Large farm sizes would for example allow the owner to diversify crop types and farming methods. The management of some communally owned resources like water sources poses a challenge when decisions on coping strategies have to be made.

Socio-economic Factors and Recovery

Age, level of education, resource tenure and size of land can affect the recovery process. The same factors that may influence coping capacity as far as age, level of education, resource tenure and size of land would influence the success of recovery. The interventions adopted are meant to rectify the situation or move the actors to another level that enables them to stabilize in a new state. These coping mechanisms are influenced by some social factors and therefore by extension, the social factors would either directly or indirectly influence recovery.

Intervening Variables

Household income, social support, health of individuals, religious beliefs, and individual perception may also impact on the coping capacities and recovery of households due to the impact of CCRDs. Where household income is solely from subsistence farming, the ability to cope with CCRDs on soils and water sources may be hampered compared to households which are not wholly reliant on the natural capital for income. Strong social support helps victims recover faster and easily besides offering them alternative coping avenues. Healthy individuals may have the energy and agility to cope with varied degrees of impacts compared to the less healthy who are more vulnerable to disturbances.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research designs and discusses the research methodology used, the location of the study, target population, sampling procedures and sample size, instrumentation, data collection and analysis procedures.

3.2 Research Design

The study employed descriptive survey research design. The study sought to assess resilience of households to CCRDs in Kisumu County specifically the impacts of floods and drought on soils and water sources. Descriptive survey research is where a researcher describes the characteristics of a particular individual or of a group (Kothari, 2004). A survey provides numeric descriptions of some part of the population and describes and explains events as they are, as they were or as they will be (Oso and Onen, 2009). It is ideal for resilience studies in this case because as Oso and Onen (2009) advanced, "Independent Variables (IVs) cannot be manipulated and should not be manipulatable". In this study, the IVs are impact of CCRDs and Social factors, which cannot practically be manipulated and the Dependent variable (DV) is Resilience, which was decomposed into coping mechanisms and recovery. This research design was suitable because it enabled collection of huge volumes of data within a short span of time using a representative population sample. Table 1 further displays the variables measured in the study.

Table 1: Variables Measured Against Each Study Objective

	Specific Objectives	Items Measured
1	To determine the impact of CCRDs on the Environment	Extent of Impacts of Floods and drought on soils and water sources (Impact Index)
2	To determine the resilience of households in lower Nyando river basin, Kisumu County	Coping mechanisms for impacts of floods and drought on soils and water sources (Coping Index) Degree of success of repairing land/soils and restoring water sources due to impacts of floods and drought respectively (Recovery Index)
3	To determine the influence of impact of CCRDs on the Environment on the coping mechanisms of households in lower Nyando River Basin, Kisumu County	- Impact - Coping
4	To establish how the Impact of CCRDs on the Environment influences recovery of households in lower Nyando River Basin, Kisumu County	- Impact - Recovery
5	To examine the influence of socio-economic factors on households 'ability to cope with the impacts of CCRDs on the environment in lower Nyando River Basin, Kisumu County	- Influence of gender on coping - Influence of age of household heads on coping - Influence of highest level of education on coping - Influence of farm size on coping
6	To investigate the influence of socio-economic factors on households' ability to recover from the impacts of CCRDs in lower Nyando River Basin, Kisumu County	- Influence of gender on recovery - Influence of age of household heads on recovery - Influence of highest level of education on recovery - Influence of farm size on recovery

3.3 The Study Area

The study was conducted in the lower Nyando River Basin that traverses Nyando, East Kano and Nyakach Sub-counties of Kisumu County. Kisumu County is administratively divided into seven sub-counties namely: Kisumu East, Kisumu West, Kisumu Central, Nyando, Seme, Nyakach and Muhoroni. These are further divided into several divisions, which are in turn divided into locations for ease of administration (Table 2).

Table 2: Administrative Units of the County

District/Sub-county	No. of Divisions	No. of Locations
Kisumu North	2	4
Kisumu East	2	16
Kisumu West	2	8
Nyando	1	6
Seme	1	5
Muhoroni	2	9
Nyakach	2	14
Total	11	57

Source: (KCIDP, 2013-2018)

The Nyando River Basin covers an area of 3,500 square kilometers in Kisumu County and its catchment straddles the equator bound by longitudes 34°45’ 0”E and 35° 21”E. (Otiende, 2009). The basin as it popularly known is found in what is also referred to as the Kano plains due to its flat terrain. The 2011 National Housing and population census estimated the population of Nyando District at 141,037 and that of Nyakach at 133,041. Poverty levels in the then Nyando district (where Nyando, Kisumu East and Nyakach sub-counties are now located) stood at 60% way above the national poverty level Kisumu County Integrated Development Plan (KCIDP), 2013-2017. Majority of the households are subsistence farmers growing food crops like maize, millet, sorghum, cowpeas, cassavas and beans. Some are either skilled or unskilled artisans and still a smaller proportion is made up of the unemployed. The study site involved locations that are prone to both floods and drought making it ideal for the study. Figure 2 shows the map of the study area.

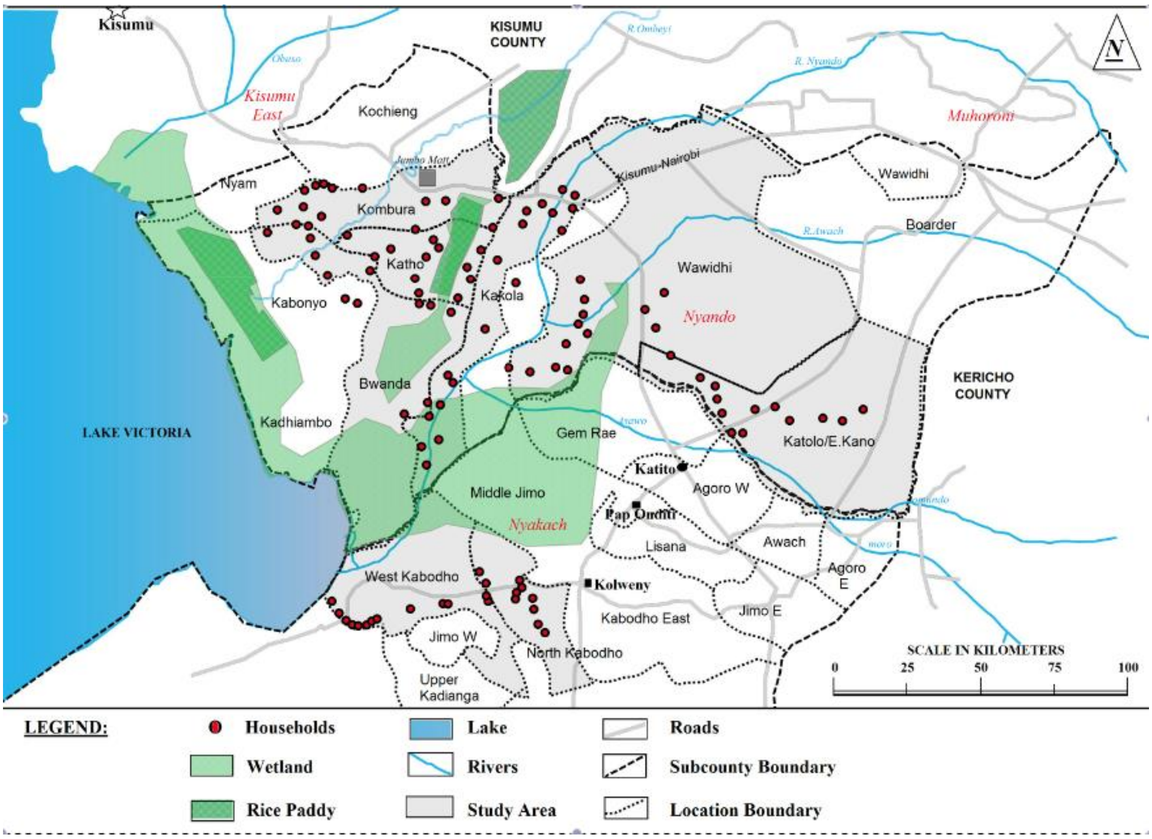

Figure 2: Map Showing the Nyando River Basin and the Study Area

3.3.1 The Physiography of the Kano Plains and Nyando River Basin

The study was confined to the lower Nyando River Basin, which is located in the Kano plains, a flood plain of the Nyando River. It borders the Winam Gulf, a protruding part of Lake Victoria, at the end of which is Kisumu town. The plain is, however, characterized by broken low ridges and river valleys (Ochola, 2009). The Nyando River has its origin in the highlands of the Nandi hills with an altitude of over 1700m above sea level. From the highlands the river flows down V -shaped valleys in the mountainous areas with an estimated bed width of 20 m and a gradient of 1: 45 (NEMA, 2004). In the middle reaches, the river meanders through a narrow valley floor with a bed width of about 40 m and gradient of 1: 160. The lower reaches of the river are characterized by pronounced meandering over a wide flood plain, the bed width is estimated to increase to about 50m and the gradient flattens further to 1: 170 (NEMA, 2004). The Nyando river catchment empties its water into Lake Victoria. It is notorious for frequent flooding. In the basin are other smaller rivers and tributaries, which also empty into the lake. These other rivers also swell during floods and contribute to the impacts in the study area. On the other hand, they form the daily source of water to the households before drought creeps in.

3.3.2 Climate of the Study Area

Nyando Sub-county is classified as semi-humid (Ochola, 2009). The Nyando River Basin experiences a bimodal rainfall pattern with long rains in March-May and short rains in September-October (Raburu *et al.,* 2012). The annual rainfall varies from more than 1,100 mm to 1600mm with a minimum and maximum mean monthly rainfall of 72mm and 243 mm respectively (Raburu *et al.,* 2012). No significant long-term trend can be recognized although large variations in annual rainfall amounts are repeatedly observed. The Kano Plains (where the study locations are) experience a humid to semi-arid climate and receive rainfall in the ranges of 600-1100mm/y (Raburu *et al.,* 2012). The relative humidity in the middle and lower basin varies between 55% and 75% in the dry and rainy seasons respectively, peaking in May and July with minimum occurring in January during the short dry season and October during the long dry season. The mean annual maximum temperature ranges from about 27^0C to about 32^0C, and the mean annual maximum temperature is recorded in June through July. The annual minimum temperature ranges from 14^0C to 18^0C, with the peak minimum temperature recorded in August through September (LBDA, 1992).

3.3.3 Soil Characteristics and Floods in the Nyando River Basin

In the Kano Plains, vertisols are the dominant soil types, and have been used for sugarcane, rice and cotton production (Ochola, 2009). The vertisols (black cotton soils) are characterized by high to moderate fertility, although subject to water logging and inundation during the long rainy season that prohibits the physiological development of the crops grown in the flood prone plain. These soils are also characterized by intractable, alluvial soils, which have very poor drainage, and suffer periodic drought and flooding. The total area annually vulnerable to flooding is 15,000–20,000 ha. This area comprises the Kisumu East, Nyando, and Lower Nyakach divisions of Kisumu County as shown in Figure 1. Available data suggest that progressively greater flooding is being caused by smaller flow in the rivers concerned (Opere, 2013). The main Nyando River, which traverses Kericho, Nyando and Kisumu counties, has a total catchment area of 2606 km^2 and is 148 km long. Its main tributary, the Ainomutua River, drains 845 km^2. The flow regime of the Nyando is varied and has occasionally been as low as 2 m^3/s and with extreme floods above 850 m3/s. Siltation is heavy. Earlier estimates of siltation rates by Italconsult are in the range of 685,000 tons per annum; however, recent assessments by LBDA for the period 2000–2003 are fourfold higher than the Italconsult findings (Opere, 2013). The study area is prone to between 3 to 7 years flood return frequency with an average magnitude of 400 m3/sec. Further results showed that out of the 31 years of continuous time series flow the Nyando River recorded 18 years of bank full flow (200 to 387.6 m3/sec). The high frequency of bank full flow shows that Nyando River has limited channel capacity and is therefore vulnerable to flooding downstream (Ochola, 2009).

3.3.4 Livelihoods or Socio-economic Activities

Poverty levels in the then Nyando District (where Nyando and Nyakach sub-counties are now located) stood at 60% way above the national poverty level reported by the World Bank poverty incidence report (2012) cited in Raburu *et al.*, (2012). A study carried out on the households of residents of Nyando River Basin indicates a high degree of poverty and low incomes reflected in the employment types where the majority of the people were in the informal sector (Nyakundi *et al*, 2010). The main occupation of a majority, (67.1%) was subsistence farming. A smaller proportion (14.4%) consists of skilled and unskilled artisans composed of carpenters, mechanics, shop owners, fishermen and vegetable vendors while a mere 6% were employed. The remaining 12.9% were categorized as unemployed. These included the jobless, students and housewives.

3.4 Sampling and Sampling Procedure

The study sought to assess resilience of households to impacts of CCRDs on the environment in Lower Nyando River Basin, Kisumu County. The following section describes the population of the study area, the target population, accessible population, sample size and sampling techniques used.

3.4.1 Population of the Study Area

The total population of Kisumu County is 968,909 (Kenya National Bureau of Statistics (KNBS, 2010). The study area was stratified according to the administrative units. Strata created layers to accommodate all the targeted sub counties; divisions and locations thus ensuring samples are drawn from them in a proportionate manner. Purposive sampling was used to select the sub-counties, divisions and locations prone to floods and drought. Three of the seven sub-counties, namely Nyando, Kisumu East and Nyakach Sub counties perennially suffer cycles of alternating floods and drought yearly (PFNA, 2013,Ajuang, Paul, Esna, Gabriel and Douglas, 2016). From the three sub counties, 3 divisions namely Nyando, Kadibo and Lower Nyakach, were selected based on vulnerability to floods and drought (Okayo *et al*, 2015). Finally the locations prone to floods and drought: 3 from Kadibo (Katho, Kombura, and Bwanda), 3 from Nyando (Kikolo, Wawidhi, and Kakola) and 2 from Lower Nyakach (North Kabotho and West Kabotho) were settled on to draw the sample population. The selected locations constitute the lower Nyando river basin and have close proximity to River Nyando and other small rivers) which predisposes them to frequent flooding during the rainy season and drought during the dry season when the seasonal rivers shrink or dry up completely

(Ajuang *et al.*, 2016, Okayo *et al*., 2015, Nyakundi *et al.*, 2012, Opere, 2013). The small rivers that traverse the area include rivers Awach, Ombeyi, Orije, Asawo, Nyalbiego and Obuso. The communities here therefore have experiences with both floods and drought. The locations selected are close to each other and this made it easy for data collection taking cognizance of the limited finances the researcher had. Kothari (2012) asserts that non-probability sampling has inherent advantage of time and money suitable for small individual researches like this study. The target population of the study was therefore all households in Nyando, East Kano and Nyakach Sub-counties, which was 162,162 (KNBS, 2010). The accessible population was made up of 14,675 households drawn from the eight (8) locations as displayed in Table 3

Table 3: Accessible Population

Sub County	Division	Location (Ward)	Households
Kisumu East	Kadibo	• Katho	1288
		• Kombura	1,767
		• Bwanda	1,260
Nyando	Nyando	• Kikolo/E. Kano	1,754
		• Wawidhi	2,036
		• Kakola	4,878
Nyakach	Lower Nyakach	• N. Kabotho	620
		• W. Kabotho	1072
		Total	**14,675**

(Kenya National Bureau of Statistics, 2010)

3.4.2 Sampling Techniques

Sampling technique is the procedure a researcher uses to gather people, places or things to study. The sampling procedure applied was as follows: Proportionate sampling was used to ensure appropriate sample size was derived from each location. Households were then selected using systematic sampling where a household was picked after every 3 households. The household heads were the respondents. Kothari, (2012) contends that proportionate allocation increases representativeness where the sizes of samples from different strata are kept proportional to the sizes of the strata. In the study area, the accessible population from each location was of a different size (Table 3) thus proportionate allocation. Observations were made and where necessary photographs were taken. The sample was drawn from the households (unit of sample) and the subject of analysis was the household heads.

3.4.3 Sample Size

The sample size was calculated using the following formula, which is applicable for finite population (Kothari, 2012).

$$n = \frac{Z^2 p(1-p)N}{e^2(N-1) + Z^2 p(1-p)}$$

Where:

n = required sample size

N = the target population size

p = the estimate proportion or the incidence of cases in the population. In this study p = 0.50, the volume that yields maximum possible sample size

Z = the value of the standard variate at the desired level of confidence. In this study, the desired level of confidence is 95% (0.95), hence Z = 1.96

e = the acceptable error, that is, the amount of tolerable error of 5% (0.05) will be acceptable, hence, e = 0.05

Applying this formula with N, p, Z and e:

Sample size, n= $\frac{1.96^2 x0.50\ (1-0.50)\ 14{,}675}{0.05^2(14{,}675-1) + 1.96^2\ x0.50\ (0.50)}$

n= 374.38

A summary of the sample size is as shown in the Table 4.

The sampling fraction is the ratio of the sample size to the population size, which in this case is 374.38/968,909, which amounts to 0.0003863934

Purposive sampling was used to identify the Key informants who are knowledgeable in the topic of study. Purposive sampling is used where the researcher decides whom to include in the sample based on their typicality (Oso and Onen, 2009). Key informants are therefore those people in the community who have specialized knowledge in some subject matter. The Key informants identified included heads of Government departments, NGOs, Administrative officers and community leaders (Appendix 4). Census method was then used to sample all the 13 key informants who had been selected through previous interactions with the research assistants.

Table 4: Summary of Sampling of the Households in the Study Area

Sub-County	Division	Location	No. of Households	Proportionate Sample Size (households)
Kisumu East	Kadibo	- Katho	1,288	32.825
		- Kombura	1,767	45.033
		- Bwanda	1,260	32.117
Nyando	Nyando	- Kikolo/E. Kano	1,754	44.701
		- Wawidhi	2,036	51.888
		- Kakola	4,878	124.318
Nyakach	Lower Nyakach	- N. Kabotho	620	15.801
		- W. Kabotho	1072	27.320
2	**2**	**8**	**12,983**	**374.003**

3.5 Instrumentation

A mixed method approach was adopted to gather the data where three instruments were developed to solicit data namely: A household survey questionnaire, an interview schedule for Key Informant Interviews (KIIs) and an Observation Checklist. The selection of these tools was guided by the nature of data to be collected, the time available and the objectives of the study. The overall aim of this study was to the assess resilience of households to impacts of CCRDs on the natural capital in Kisumu county. A mixed method approach allows for confirmation of facts gathered by one instrument and therefore gives validity to the data.

3.5.1 Questionnaire

A questionnaire is a collection of items to which a respondent is expected to respond, usually in writing (Oso and Onen, 2009). This instrument was adopted for this study as it has proved to be the effective in surveys to gather data that measure issues crucial to the management of human resources such as behavior, attitudes, beliefs, opinions, characteristics and expectations (Pea and Parker, 2012). A Household questionnaire (Appendix 1) was constructed using closed ended multiple-choice items. The items yielded information on the Bio-data of respondents, history of use of natural resources and, nature and intensity of floods and drought experienced in the locality, impact of floods and drought to the soils and water sources, Coping capacities and ability of households to recover from impacts of CCRDs. The questionnaire enabled the researcher to collect a huge volume of data and ensure consistency in the answers. A questionnaire is used to collect a lot of information over a short period of time. This method therefore is very suitable for this study whose sample size is large (374 household heads) administered within a short period of time. The information needed can also be easily captured in writing. The questionnaire yielded both qualitative and quantitative data on household resilience to CCRDs. Likert scale-like responses were used.

3.5.2 Key Informant Interview Schedule/Guide

Interviews are person-to-person communication in which one person or a group of persons (interviewer) asks the questions intended to elicit information or opinions from the respondent (interviewee). Interviews are used to collect information that cannot be directly observed or difficult to put down in writing. Interviews can capture meanings beyond words (Oso and Onen, 2009). This study involved variables that could not be observed directly such as opinions, perceptions and attitudes of the respondents and therefore the interviews allowed interrogation of the facts to bring out the clearer picture. A key informant interview schedule (Appendix 3) was used to collect data on the prevalence of floods and drought, the impacts of floods and drought on soils and water sources, coping capacities of the households and their ability to recover from CCRDs, levels of preparedness to cope with CCRDs, the roles of the institutions represented in as far as CCRDs in the area is concerned. Each interview lasted between 30 minutes to one hour. The researcher facilitated the interviews and sought clarification where the responses were not clear while the research assistant took notes as the interview progressed. The interviews were conducted in both English and Luo languages at the convenience of the respondent. The Key Informants (KI) were selected based on their roles in the relevant disciplines and institutions and also knowledge of and interaction with the functions and communities in the study area. Thirteen (13) Key Informants (Appendix 4) were selected based on their roles and interaction with the flood and drought prone community. KIs are people with specific knowledge and experience of floods and drought. They represented opinion leaders, experts and practitioners in the area who handle flood and drought issues by virtue of the offices they hold or status in the society. They included the following: A public health officer, a meteorological assistant, 2 environmental officers, water officer, agribusiness officer, 2 administrators (2 chiefs and assistant chief), project coordinator (world vision), an Agronomist, a Red cross focal coordinator, an Agrovet, and a Flood control chairperson, Repeat visits and calls were made until appointments were secured.

3.5.3 Direct Observation Checklist

Observation technique uses all senses to perceive and understand the experiences of interest to the researcher (Oso and Onen, 2009). Observations allow the researcher to see what people actually do rather than what they say they do and it also bridges the gap between what people say they do and what they actually do. Using an observation checklist (Appendix 2), the research assistants were able to systematically watch and record the coping mechanisms of households. They were able to gather firsthand information and documented any unusual aspects that the informants were uncomfortable to discuss or state. Photographs were taken to support the observations made where applicable. Observations yielded information on the coping interventions/measures the communities engaged in and their general wellbeing. This method helped to relate the observed findings to the data generated from questionnaires.

3.5.4 Pilot Study

Piloting of the instrument was done for one week. The pilot study was conducted in Anding'o Opanga location in the neighboring upper Nyakach division that was not involved in the study. The pilot study was undertaken to test the applicability of the questionnaire and to identify weaknesses in the questionnaire, which were then revised in readiness for the actual study.

3.5.5 Validity of the Research Instruments

Quality control refers to ensuring acceptable levels of validity and reliability of the study through proper control of extraneous variables (Oso and Onen, 2009). Validity refers to the ability of a research instrument to generate the intended data (Kothari, 2004) or the degree to which a research instrument reflects reality. Experts comprising lecturers from the department of Environment at Kabarak University validated the three instruments (questionnaire, interview guide and observation guide) for face and content validity. In most cases, the questions were rephrased for clarity where ambiguous terms were replaced with specific terms and complex terms were simplified to the level of the respondents. Test items to cover all the objectives were included and where items constructed would yield the same responses, one of them was omitted to avoid repetition. The recommendations given were used to improve the document before using it to gather the data.

3.5.6 Reliability of the Research Instruments

Reliability refers to the consistency of a research instrument (Kothari, 2004). This means that reliability is concerned with the extent to which a research instrument produces the same result when administered repeatedly. The household heads' questionnaire was piloted for reliability using a sample of 22 respondents drawn from Anding'o Opanga location in upper Nyakach Division, which was not involved in the study. The number (n = 22) of the household heads who took part in the piloting was determined using a sample size of between 20 to 25 subjects, as recommended by Drofe (2011). The reliability of the instrument was estimated using the Cronbach Alpha formula (Institute of Digital Research and Education, 2016). The formula is: Cronbach Alpha $\alpha = K.c / [v + (K - 1) c]$ Where K is the number of items in the test tool.

c is mean inter-item covariance among the items

v is overall mean variance

The Cronbach Alpha method was selected because the household heads' questionnaire was constructed using close-ended multiple-choice items and was administered once during the piloting. This method has been recommended for estimating reliability of instruments that are constructed using polychotomously scored items (Mertens, 2010). The Statistical Package for Social Sciences (SPSS) aided in the estimation of reliability. The estimated reliability coefficient of the questionnaire was 0.880 (Appendix VI). This was an indication that the instrument was reliable since its coefficient was above the 0.7 threshold recommended for educational and social science researches (Ritter, 2010).

3.6 Data Collection Procedures

In preparation for data collection, the researcher secured an introductory letter from the Board of Post Graduate Studies, Kabarak University that was used to seek a research permit and research authorization letter (Appendix VII and Appendix VIII respectively) from the National Council of Science and Technology (NACOSTI) in the Ministry of Education, Science and Technology. Two research assistants were recruited and trained on the use of the instruments to enhance understanding the focus of the research, recording and reliability of information. The training took place prior to piloting of the research instruments. During the training, the researcher explained to each enumerator how to fill the questionnaire and how to conduct themselves during the interviews. After revision and thorough understanding of the instrument the researcher then informed the local administration of the proposed study. The message was relayed to people through churches and barazas. A schedule of activities was then drawn in consultation with the local administration and actual data collection commenced and this lasted eight weeks. For each respondent, the interviewer explained the objective of the study and sought his or her consent to participate in the study. The surveys were conducted in local language by the research team and later translated into English.

3.7 Data Analysis Procedures

The data collected was coded, screened and cleaned. SPSS was used to prepare a data file and the coded data was keyed into it. Frequency, percentages, and means were used to describe and summarize data. The study hypotheses were tested at the .05 level of confidence. Differences in impact of CCRDs by division were determined using the Analysis of Variance (ANOVA). The influence of impact of CCRDs on resilience (coping and recovery) was established using simple linear regression. The procedure was selected because it is ideal for establishing causal relationships between variables and also explaining the power of each independent variable in accounting for variations in the dependent variable (Tabachnick & Fidel, 2007). Differences in resilience by division were determined using the Analysis of Variance (ANOVA). This technique was chosen because it is recommended (Field 2017) for comparing the means of more than two groups that were measured at ratio or interval scale. The influence of socioeconomic factors on resilience (coping and recovery) was established using multiple regressions. This procedure was selected because it is ideal for analyzing associations between two or more independent variables and a single dependent variable, which may be either continuous or categorical (Salkind, 2010). A summary of the statistical data analysis tools and their application is given in Table 5.

Table 5: Summaries of the Statistical Data Analysis Tools and their Application

3.8 Ethical Considerations

Specific Objectives	Independent Variable	Dependent Variable	Analysis Tool	Output
1. To determine the Impact of CCRDs on the Environment	Floods Drought	Soils Water Sources	ANOVA	Impact Index
2. To determine the resilience of Households in lower Nyando River Basin, Kisumu County	Impact	Resilience	ANOVA	Resilience
3. To determine the influence of Impact of CCRDs on the environment on the coping mechanisms of households in lower Nyando River Basin, Kisumu County	Impact	Coping Mechanisms	Simple linear Regression	Resilient households
4. To establish how the Impact of CCRDs on the environment influences recovery of households in lower Nyando River Basin, Kisumu county	Impact	Recovery	Simple linear Regression	Resilient households
5. To examine the influence of socio-economic factors on the households' ability to cope with effects of CCRDs on the environment in lower Nyando River b Basin, Kisumu County	Social factors	Coping capacity	Multiple Regression	Resilient households
6. To investigate the influence of socio-economic factors on households' ability to recover from the effects of CCRDs on the environment in lower Nyando River Basin Kisumu County	Social factors	Recovery	Multiple Regression	Resilient households

During the data collection, utmost confidentiality was maintained by ensuring the respondents' names were not captured. Consent was sought from each respondent to ensure they were willing participants in the research. The researcher exercised honesty in reporting the outcome of the research and did not impose ideas on the respondents.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

This chapter presents the findings, interpretations and discussion according to the following six specific objectives: i) to determine the Impact of CCRDs on the Environment of households in lower Nyando River Basin, ii) to determine the resilience of households in lower Nyando River Basin, Kisumu County to the impact of CCRDs on the environment, iii) to determine the influence of Impact of CCRDs on the environment on the coping mechanisms of households in lower Nyando River Basin, Kisumu County, iv) to establish how the Impact of CCRDs on the environment influences recovery of households in lower Nyando river basin, Kisumu County, v) to examine the influence of socioeconomic factors on the households' ability to cope with impacts of CCRDs on the environment in lower Nyando river basin, Kisumu County, vi) to investigate the influence of socioeconomic factors on households' ability to recover from the impacts of CCRDs on the environment in lower Nyando river Basin Kisumu County. The results either rejected or accepted the following six hypotheses: H_{01}: There is no significant difference in Impact of CCRDs on the environment of households in lower Nyando River Basin Kisumu County. H_{02}: There is no statistical significant difference in resilience of households to impact of CCRDs on the environment in lower Nyando River Basin Kisumu County, H_{03}: Impact of CCRDs on the environment has no statistical significance on coping mechanisms of households in lower Nyando River Basin Kisumu County, H_{04}: Impact of CCRDs on the environment has no statistical significance on the recovery of households' in lower Nyando River Basin Kisumu County, H_{05}: There is no statistical significant influence of socioeconomic factors on households' ability to cope with effects of CCRDs on the environment in lower Nyando River Basin Kisumu County and H_{06}: Socioeconomic factors do not significantly influence recovery of households from the effects of CCRDs on the environment in lower Nyando River Basin Kisumu County.

4.2 Instruments Return Rates

The study used three instruments, Household Heads Questionnaire (HHQ), Observation Checklist (OC) and Key Informant Interview Guide **(**KIG) to collect data. A total of 374 HHQs were administered to the respondents. Out of this number 93.9% (352) were returned. 3 of the returned HHQ were not used when generating the study results as they were either not filled or partially filled. 93.1% (349) of the administered HHQ were thus used to generate the results of the study. All the 12 Key Informants (KIs) were interviewed giving 100% participation. The details of the KIs are in appendix 1. In total 32 observations were made by the researcher following the Observation Checklist (Appendix 2). Four (4) observations were made in each sub location as the interviews continued and pictures were taken to corroborate the responses from the respondents. The high HHQ response rates was achieved because the researcher put in place mechanisms to enhance return rates such as: creating good rapport with household heads, repeated visits, sending reminders, extending data collection duration, assuring the subjects that the collected data would be used for research purposes only. The questionnaires returned were deemed adequate for analysis. Babbie and Mouton (2001) consider a response rate of 50 per cent adequate for analysis and reporting while 60% is good, 90% is excellent. It can be concluded that the data collection proceeded as envisaged and sufficient amounts of data were gathered for the study.

4.3 Findings of the Study

The findings of the study are presented sequentially from demographics, impacts of CCRDs (Floods and Drought) on the environment (Soils and Water sources), coping with impacts of

CCRRDs, Recovery from Impacts of CCRDs and finally, the relationship between coping, recovery, impact and Social factors.

4.3.1 Characteristics of the Respondents

The characteristics of the HHDs were first analyzed by age, marital status, land tenure, distance from river channel, gender, farm size, activities engaged in on farm, level of education as indicated in Table 6. This data was later used to conduct further analysis in testing objectives four (4) and five (5).

Marital Status

72% of the respondents were married, followed by 25.7% who were widowed, 1.4% who were single and the minority 0.9% divorced as (Table 6). These results depict a picture where most households are complete and division of labor between men and women can easily be attained for the benefit of exploiting different gender-sensitive livelihoods and concerted efforts at mitigating the impacts of CCRDs consultation at household level.

Land Tenure

Most respondents 94.8% own land, a few 15% lease land and the minority 0.9% rent land (Table 6). This depicts the situation on the ground as per Kisumu County Integrated Development Plan (KCIDP), 2013-2017. Land ownership determines the extent of modifications, investment and security that one can undertake and hence it is a crucial parameter in this study. If self-owned, the owner has the leeway to do as they like on the land but if leased, there are limitations (Malel, 2020).

Table 6: Characteristics of the Respondents

Scale	Characteristic	Frequency	Percentage
Marital status (n = 346)	Married	249	72
	Single	5	1.4
	Widowed	89	25.7
	Divorced	3	0.9
Land tenure (n= 348)	Rented	3	0.9
	Leased	15	4.3
	Owned	330	94.8
Distance from river channel (n = 345)	Below 1 km	215	62.3
	1.00 - 1.9	61	17.7
	2 - 2.9	32	9.3
	3.0 - 3.9	20	5.8
	4 km and above	17	4.9
Gender of HHHs	Male	202	58.2
	Female	145	41.8
Age of HHHs	35 years and below	39	11.2
	36 – 45	90	25.9
	46 – 55	98	28.2
	56 – 65	57	16.4
	66 years and above	63	18.2
Highest Level of Education of HHHs	None	15	4.3
	Lower primary	30	8.7
	Upper primary	161	46.7
	Secondary school	100	29
	Tertiary	39	11.3
Size of farms owned by HHHs	2 acres and below	212	61.3
	2.1 - 4.0	109	31.5
	4.1 - 6.0	19	5.5
	6.1 acres and above	6	1.7

Distance From River Channel

80% of the respondents live within 2km from a river channel, while 20% live beyond 2 km from a river channel as shown in Table 6. Okayo *et al,* (2015) reported that 2 km is within the flooding range zone and therefore in this case, 80 % of the households can be considered as being vulnerable to flooding. It is therefore expected that the majority of people would take up precautionary measures against floods given the proximity to flood prone rivers. Being close to rivers is also an advantage in that water is easily accessible. People in such areas are thus advantaged in that they spend less time in reaching the water sources. The time saved can be invested in working on the farms to increase food production. People living near rivers harness the river water for small-scale subsistence irrigation of vegetable gardens along the riverbanks during the dry season. Besides being an illegality for failure to observe the riparian boundaries (EMCA 2015), it is also a maladaptation. The gains from the vegetable gardens may be substantial at the moment, but the effects of cultivating riparian are cumulative and erosive.

Gender of Household Heads (HHHs) Interviewed

Gender was defined by sex, either male or female for purposes of study.58.2% of the household heads interviewed were male and 41.8% were female (Table 6). These results are consistent with traditional roles where men are the heads of households. In a polygamous community typical of the study area, most household heads are expected to be men. The role of gender may also influence land use, as women must also carry out other duties besides farming. Such duties include looking for firewood, cooking, general hygiene maintenance of the home. Having men take up the role of household heads is advantageous as reported by Okayo *et al.*, (2015) who reckons that men have greater responsibilities when it comes to flood. These responsibilities include rebuilding houses swept away by floods, taking dependants to hospital should they fall sick as a result of water borne diseases and ensuring that food is availed during drought. Women who perform general hygiene maintenance of homes and feeding of households (Opondo, 2013) would complement their efforts.

Age of Household Heads

The majority of the household heads (54.1%) were between the ages 36-55, which is the most productive age, is. The age distribution of household heads is captured in Table 6.

Highest Level of Education of Household Heads

Most of the respondents had a minimum upper primary level of education (46.7%) and 8.7% lower primary education (Table 6). The low levels of education could be attributed to high poverty levels and lack of motivation to pursue higher education (Nyakundi, 2010). The finding means that, by and large, the respondents were progressive in pursuit of education but they were still far away from the higher education, which is so important today to create a knowledge-based society. Omungu (2014) in Okayo *et al.*, (2015) concurs that the Nyando community lacks awareness on flood disaster. The low levels of education in the study area could also be attributed to the culture. Being close to River Nyando and Lake Victoria, most people concentrated on fisheries as a livelihood, scenario, which has since changed due to dwindling fisheries resources and shift to non-fishery, based livelihoods (Raburu *et al.,* 2012). The results contrast with the findings of Feleke *et al.,* (2016) who reported 34.6% illiterate household heads in Tigray, Ethiopia. Their study showed that the sheep and goat farmers' choices of adaptation strategies were statistically and significantly affected by factors such as access to information, farming experience, distance to main market, household income, agro-ecological zone and number of households in a village. They opined that a literate population could internalize new concepts and interpret scenarios.

Size of Farms of Households

In terms of farm sizes, majority (61.3%) of the household heads had farm sizes of 2 acres and below (Table 6). The mean of the farm sizes in acres was M=2.27. Oluoko-Odingo (2006) noted that land sub-divisions might result into uneconomical units, or loss of titles, where farmers are not able to pay their debts and as such problems are ultimately linked to food insecurity and poverty. Households in the study area therefore risk food insecurity and this is likely to worsen as more households are established when men come of age, a cultural practice that is greatly revered. One old man in Kakola location confirmed that the farm sizes are shrinking with each subsequent generation who follow in the tradition of bequeathing land to their sons who come of age in order to enable them establish their own homesteads. Farms that were formerly cultivated are converted into homesteads in the process.

Activities Households Engage in on Their Farms

The respondents utilize their farms for subsistence crop farming, cash crop farming, livestock keeping, vegetable farming, fruits farming and other economic activities like brick making, basketry and tree planting. This is typical of communities in the study area. Table 7 shows the distribution of activities households engage in on their farms.

Table 7: Activities Households Engage in on Their Farms (n =349)

Activity	Frequency	Percentage
Growing subsistence crops (maize, beans, cassava, millet, sorghum)	329	94.3
Cash crops farming (sugarcane, rice, cotton)	36	1.3
Keeping livestock (cattle, sheep, goats, donkeys, poultry)	123	35.2
Growing vegetables (sukuma wiki, kunde, onions, tomatoes)	65	18.6
Fruits farming (water melons, bananas)	15	4.3
Other economic activities (brick making, basketry, tree planting)	7	2.0

The results indicate that households engage in multiple activities that utilize both soil and water for their sustenance. Both subsistence and/or cash crop farming is practiced on land and utilizes water. Livestock keeping is also highly dependent on water for pasture and for drinking, brick making, basketry and tree planting also depend on soils and water hence initiatives and practices that build resilience of the natural capital to CCRDs should be encouraged in this community. A big percentage of households practice subsistence farming (94.3%) compared to those who do cash crop farming (1.3%). Similar findings were also reported in the KCIDP (2013-2017) report where a majority of households in the county depend on crop farming as a source of income. In Sub-Saharan Africa, economic resources are meager and this restricts diversification into alternative livelihoods yet the popular subsistence agriculture is most vulnerable to the effects of environmental degradation and climate change (Seline, Delia, Oluyede, Ajayi, Sileshi and Maarten, 2014) and hence a threat to food security. This means that, agricultural practices should be checked lest poor farming practices in this community contribute to environmental degradation. Secondary data on crop production from Nyando Sub-county over the last five years confirm that households plant a variety of crops. The production has been fluctuating due to reasons ranging from drought, variable rainfall and in some instances, infestation by fall armyworms. The production in Metric tons and acreage of selected food crops in Nyando from 2014 to 2018 is represented in Figures 3 and 4 respectively. Maize is no longer the monopoly food crop and households have adopted other crops (Figure 3). Sweet potatoes production seems to be rivaling that of maize as a food crop. Rice production shows a consistency like no other crop and this is attributed to the fact rice here is planted under irrigation and is therefore not so vulnerable to drought as opposed to maize, which is not under irrigated farming.

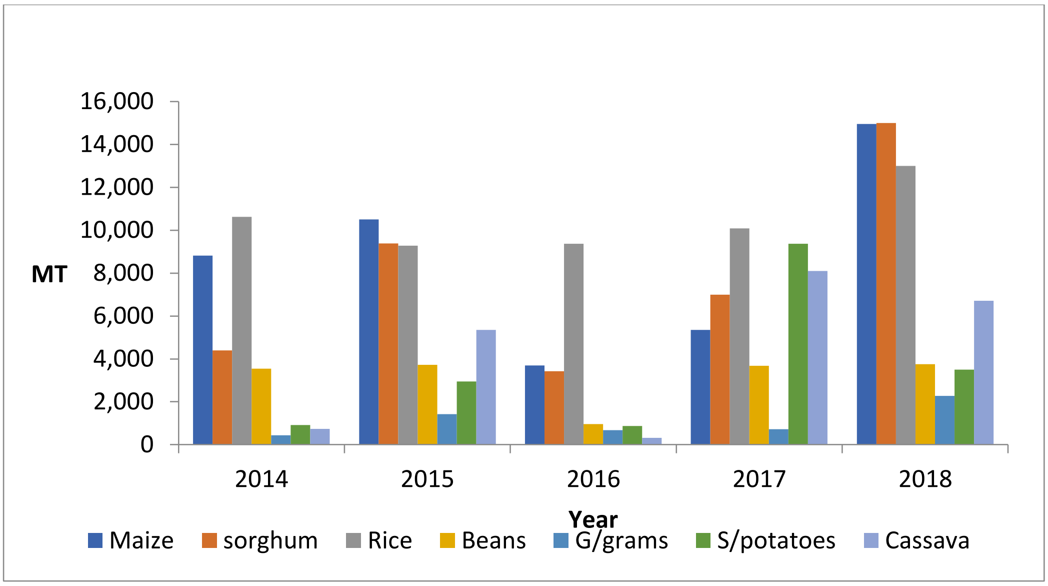

Figure 3: Selected Crop productions in Nyando Sub-county From 2014-2018.

The source of the data at the county director of Agriculture office attributed depressed cereal production in 2017 to the fall armyworms outbreak in 2017. Poor rains experienced during the short rain season affected rice production due to low volume of water in the streams.

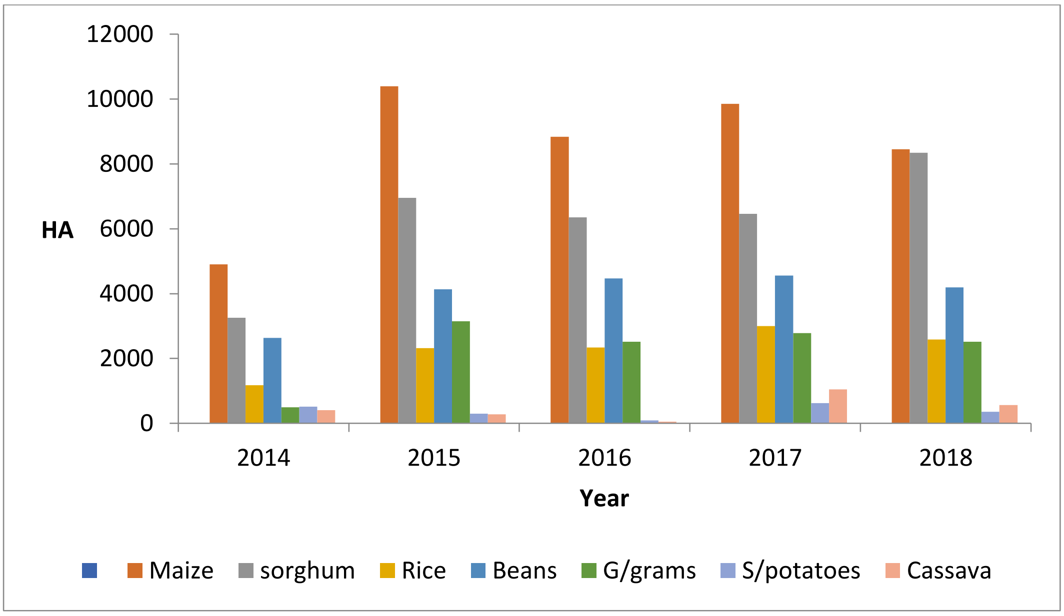

Figure 4: Acreage (Ha) of Selected Crops Production in Nyando Sub-county (2014-2018)

Figure 4 shows a steady increase in the acreage of cereals (sorghum) over the years. This was attributed to vigorous campaigns to improve foods security by the county Government of

Kisumu. The shift towards more drought tolerant food crops such as sorghum, could be an indication of adaptation to climate change. Such outcomes could be pointers to the power of extension services in influencing adaptation to climate change. There was also a drop in the amount of precipitation during both long and short rains in 2016 and this saw a drop in the acreage of crops cultivated.

The second part of the data analysis deals with the six main objectives of the study. The impacts of floods and drought (CCRDs) on soils and water sources was first determined and expressed as an index denoting Impact of CCRDs on the environment. Resilience (coping and recovery) was then assessed in two major steps starting with determination of the frequency of engaging different strategies to cope with the effects of CCRDs. This was expressed as an index denoting coping capacity. The second major step involved the determination of the success rate of the various coping means that the households use and this culminated in an index used to express recovery. These indices were used to determine the resilience (objective 2). The relationship between coping and Impact was then derived in order to determine the influence CCRDs on the environment has on coping. The relationship between recovery and impact of CCRDs on the environment was also derived in order to determine the influence of CCRDs on recovery of households. These two were used to address both objectives 3 and 4. In order to address objectives 5 and 6, the relationship between socioeconomic factors and coping index and socioeconomic factors and recovery index was derived to determine the influence that socioeconomic factors have on coping capacity and recovery respectively. The subsequent sections present and discuss the results sequentially by objective.

4.4 Objective 1: Impact of CCRDs on the Environment

The first objective of this study was to determine the Impact of CCRDs on the Environment of households in lower Nyando River Basin of Kisumu County. To achieve this, the impacts of floods on soils, impacts of floods on water sources, impacts of drought on soils and impacts of drought on water sources were determined. The selected variables are the key indicators of coping with impacts of CCRDS on soils and water sources. The steps are as follows:

Impacts of Floods on Soils

Asked whether the respondents experience floods, 96.8 % of respondents reported experiencing floods with a small percentage (3.2%) reporting having had no experience of floods at all (Table 8).

Table 8: Percentage of Households Experiencing Floods (n =349)

Response	Frequency	Percentage
Yes	334	96.8
No	11	3.2

The HHHs were further interrogated on the frequency of floods experienced in a given year. Approximately 68.2% experience floods often, 11.6% occasionally, 18.2 % rarely and a paltry 2.1% have never experienced floods (Figure 5).

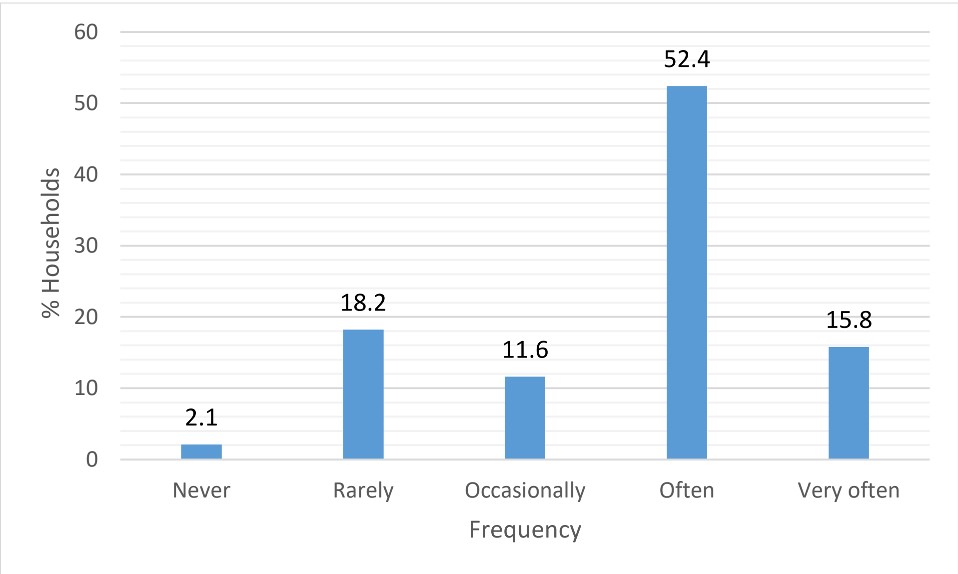

Figure 5: Frequency of Floods in a Given Year

The results are consistent with those of (Opondo, 2013) who also reported frequent incidences of floods in the study area hence a confirmation that the area is indeed a flood prone area. Impacts of floods on soils were then assessed using a set of indicators. According to Cardoso *et al.*, (2013) indicators of soil health can be grouped into three categories namely physical, chemical and biological. A critical review of the use of each of these categories of soil health in predicting sustainability of production systems led to a conclusion that none of them can stand alone but rather, a systemic approach based on different kinds of indicators (physical, chemical and biological) in assessing soil health would be safer than using only one kind of attribute. In this study selected impacts (variables) emanating from biological, chemical and physical processes were considered. The extent to which each variable (effect) is affected by floods was weighted on a scale of 1-5 denoting: No extent, little extent, moderate extent, large extent and very large extent respectively. The effects included washing away top soil, solid waste contamination, chemical contamination from fertilizers and pesticides, creating gullies, leaching nutrients, eroding vegetation, introduction of invasive species, water logging, soil and sediment contamination and reduced soil fertility. The mean of the effect on each variable was then calculated and the average mean derived to form the Impact of floods on soils Index (Table 9). This index refers to the cumulative impact of the CCRDs on soils in the study area. The threshold for high impact is $M \geq 3.0$.

Table 9: Impact of Floods on Soils Index

Effect	**n**	**Mean**	**SD**
Washing away top soil	341	2.68	1.00
Solid waste contamination (mud and debris)	339	4.05	1.07

Contamination with chemicals (fertilizer and pesticide residues)	339	3.88	1.16
Creating gullies	336	2.80	1.36
Leaching nutrients in the soil	338	3.65	1.30
Eroding vegetation cover	330	3.56	1.28
Introduction of invasive species (e.g. Cuscuta-nyar Nandi)	335	3.82	1.25
Water logging	337	3.14	1.29
Soil and sediment contamination	338	4.33	0.99
Reducing fertility	337	3.93	1.16
Impact of floods on soil index	**343**	**3.52**	**0.75**

The results indicate that the impact of floods on soils is heavy (M=3.52). The extent of impact on the invisible variables like washing away top soil (M=2.68) was relatively low compared to the rest probably because it is hard for the community to measure or even appreciate. However on more tangible aspects, they recorded high means for example, reduced soil fertility (M=3.93 in Table 9). Thorlakson (2011) reported similar results in Nyando after the 2010 floods where many farmers complained of decreased soil fertility due to intense soil erosion during the heavy rains. From the results in Table 9, the high impact on Soils and sediment contamination (M=4.33), solid waste contamination (M=4.05) and contamination with chemicals (M=3.88) points to poor means of soils remediation techniques. Contamination by chemicals was interpreted by the presence of algal blooms in pools of water on the farms whereas soils and sediment contamination was inferred by the change in texture of the soils. Soil and sediment pollution is a common problem due to floods and the deposition of silts, sediments, debris and gravel may degrade the agricultural land especially if erosion is a common phenomenon in the source area, which over time will have lost its fertility (Opere, 2013). Subsequently, the receiving area does not benefit from any fertile alluvial soils. Attributes with a rapid response to natural or anthropogenic actions are considered good indicators of soil health. Among the physical indicators, soil texture, aggregation, moisture, porosity, and bulk density have been used (Cardoso *et al*, (2013). The community members could interpret the soil texture by feeling it. Out of experience of tilling the same piece of land, year in, year out, mostly by animal drawn ploughs or by hand, they have learnt to read the changes in soil texture. An old man in Kikolo East location illustrated the difference between fertile and poor soils in the simplest terms:

> *"Loo momeo en rateng kendo ngwe maber. To loo modhier wange olil kendo otaratara kanyo"* translated *"Fertile soils are deep in colour (dark) and have a sweet aroma (characteristic smell), but poor soils look pale and lack the characteristic smell"*

The impact of Invasive species on soils was also high (M=3.8). The Key informants and households heads reported emergence of invasive species which they said are brought by either the rains as in the case of *Rwatarwata* (local name) in rice fields "and Cuscuta spp locally referred to as "nyar Nandi" (Plate 1) in reference to its origin, the Nandi highlands or they thrive in soils that have been degraded as a result of floods (cactus species and striga on bare degraded soils). Responses from the Key informants on impacts of CCRDs on the environment were consistent with those of the household survey. The emergence and establishment of some weeds namely "rwatarwata" (on rice fields), Aloe Spp (on degraded soils) and parasitic invasive weed (Cuscuta) commonly known as field dodder (Plate1) are also attributed to effects of CCRDs. The rapid spread of the field dodder is partly facilitated by its floral appeal, the ignorance of farmers and lack of tried and tested scientific control mechanisms. A picture of some of the invasive species observed in the study area and which could be attributed to soils that are degraded are depicted in Plate 1.

Invasive alien species, according to the Convention on Biological Diversity, are plants, animals and other organisms that are non-native to an ecosystem, and may adversely affect human health and the environment, including decline or elimination of native species. Whereas some are intentionally introduced such as *Prosopis juliflora* for rehabilitation of over-grazed and over-exploited semi-arid woodlands in Baringo District, others are unintentionally introduced through agents like wind, water, people and transportation vessels with ballast water. The negative effects of invasive alien species on biodiversity can be intensified by climate change, habitat destruction and pollution. Land degradation or disturbances are among the main drivers of plant invasions (Arne, Tim and Brian, 2018). Disturbances to plant communities include such events as fires, storms, and floods; but other changes such as altered grazing regimes or nutrient inputs would also be classified as disturbance if they affect resource levels and demographic processes (Wambua, 2010). Arne *et al.,* (2018) noted that despite the prevalence of invasive species and their consequent impacts on biodiversity, biodiversity issues are not at the top of the development agenda for most countries in Africa, possibly as a result of the fact that the links between biodiversity protection and the broader socio- economic welfare of human societies remain poorly understood.

Plate 1: Invasive Weeds on Farmlands

As such, research should possibly focus more on the socio-economic impacts of Invasive Alien Species (IAS) to demonstrate their significant impacts on livelihoods. Research should also focus on the costs and benefits of IAS management. In the study area, the farm dodder for example is spreading fast, decimating hedges and fences (Plate 1) which happen to be the very basic infrastructural investments that households use to secure their land, fuel source, shade and soil cover. The secondary benefit of soil conservation is therefore lost when the weed kills them. So far, the community has not deciphered how to deal with the problem apart from pulling down or burning the fences and hedges and planting other less vulnerable species. According to Nicholas Okeya, a news reporter in the area, the infestation of *Cuscuta campestris* is real and farmers have a hard time grappling with its management as captured in the words of one farmer, Julius Otieno from Homa Bay County***:***

"My live fence is almost falling down. Besides that, my grazing land is completely

covered by this yellow weed that has adamantly refused to go away. I have tried to burn it, bury it and cut it in pieces but it keeps multiplying."

The author goes on to portray a picture of where even other African countries who are facing similar infestations are yet to figure out how to control it, as reported by Ngare, Kenyatta University,

"It will be nearly impossible to control this weed in the next decade if national governments fail to take quick action."

The same could be said of the "rwatarwata" whose identify could not be established since it was collected in non-flowering state. Unsuitable land uses and inappropriate land management practices such as slash and burn agriculture, timber and charcoal extraction, deforestation, overgrazing, cultivation on steep slopes, uncontrolled fires and pollution of water resources (Arne *et al.*, 2018) all cause significant disturbances which facilitate plant invasion.

Reduced soil fertility was also rated high (M=3.93 shown in Table 9) contrary to common belief that floods inundate the lowlands depositing fertile alluvial soils (Nyakundi *et al.*, 2010). This can be interpreted to mean that soils in the highland area where river Nyando and other smaller rivers traverse, have lost their fertility due to changing land use patterns and poor farming practices. The reduced soil fertility reported is similar to the findings of a soil survey carried out in Kenya, which showed that in Nyando Sub County, 92% of farms have Total Organic Carbon (TOC) below adequate level and, therefore, low soil organic carbon matter content (KCIDP). Waterlogging was also high (M=3.14) and this is due to the flat terrain in the study area and the vertisols (black cotton soils), which are subject to waterlogging (Ochola, 2009). Most of the gullies are created on the roadsides and in the existent water channels (Plate 2) hence the relatively low rating (M=2.8). Floods have been known to contribute to leaching besides washing away the topsoil hence the high impact reported. Erosion of the vegetation cover by floods is serious (M=3.56) because literally the entire crop is wiped out leading to crop failure or nil harvest. Some plants also die out once the land is covered by water due to inhibited respiration. Leaching occurs in waterlogged soils. The danger posed by cumulative effects mentioned above if not mediated is that over the years, the soil texture and function will degrade with subsequent loss of soil productivity. Overall, the impact of the various variables is high as confirmed by the final index (M=3.52).

Plate 2: A Gulley in an Existent Water Channel in Lower Nyakach

In summary, the impacts of floods on soils are many and can be lumped together in order of prevalence as follows: Surface soil and sediment contamination, reduced fertility, introduction of invasive species and erosion of vegetation cover. Effort must therefore be made to mitigate the impact of floods on soils.

Impacts of Floods on Water Sources

The respondents were asked to state the sources of water for households, the location of the water sources, the main uses of water by households, the major pollutants of the water sources and impact of floods on the water sources. Figure 6 shows the sources of water for households.

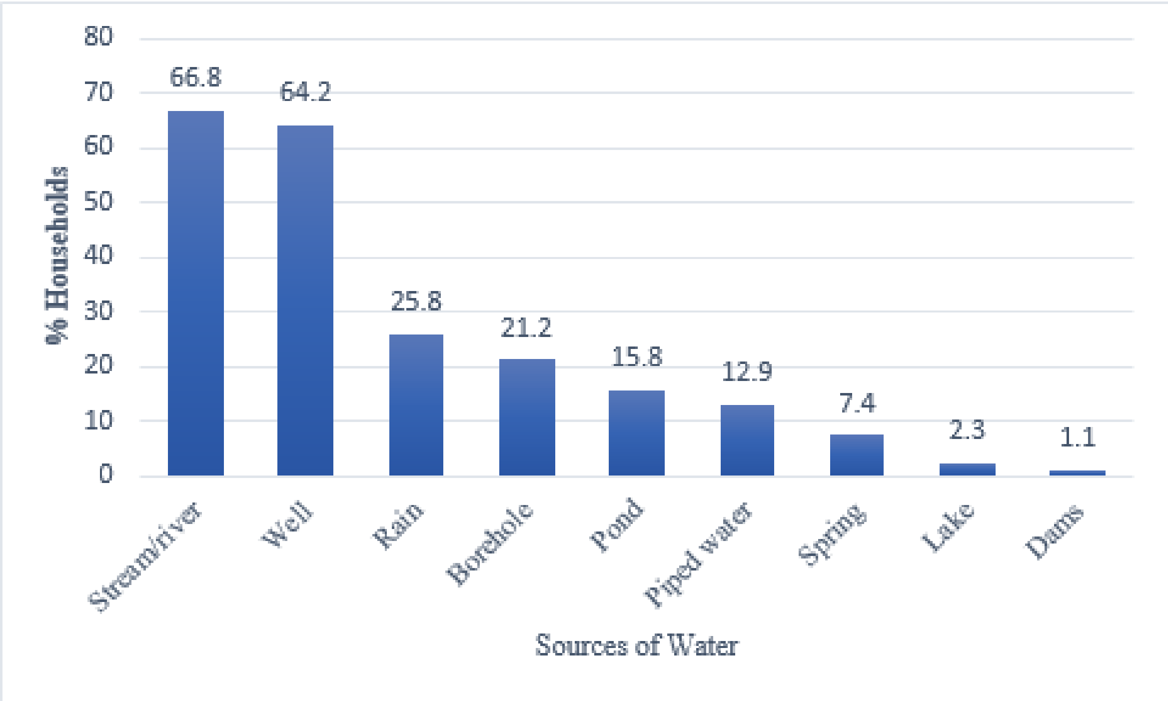

Figure 6: Sources of Water for Households

From the results, stream/river water is the main source of water representing 66.8% of the respondents followed by Wells (64.2%), rainwater (25.8 %), borehole (21.2%), ponds (15.8%, piped water (12.9%), springs (7.4%), lake (2.3%) and the least used is dams (1.1%) as in Figure 6. From the results, rivers and streams are the most common sources of water. This can be explained by the fact that at least 80% of the households live within 2km from a river channel (Table 6). The implication of this is that the households are vulnerable to hazards like floods from swollen rivers and streams. The second most popular source of water for the households is the wells. Most wells in this area have been constructed courtesy of the support of NGOs and CBOs in the area according to key informants. Few households rely on rainwater probably due to the high cost of storage facilities and installation of gutters on the roofs. This was reiterated by key informants who suggested that community members could form groups commonly known as *"Chamas"* through which they could contribute towards buying water tanks for each other in turns. The members could also seek loans to buy and install gutters for rainwater harvesting for domestic use. Boreholes are the fourth most popular source of water. Most boreholes are communal and distantly placed in schools, churches hence the low rate of usage. In addition, community members have to pay some fee to get the water. The other sources of water such as ponds, springs, lakes and dams are not used much probably due to distance and quality of water. Besides, these tend to dry up during the dry seasons. Piped water is beyond the reach of many households in the study area whose poverty index has been reported to be very high. Nyakundi *et al.,* (2010) found out that slightly below a quarter 142 (24.2 %) of households in the study area had access to communal, piped tap water. Further discussions established that access to clean piped water was a major problem and further diminished during the flood season. The water sources are almost equally distributed on individual farms, government land and community land (Figure 7). The implication of this is that accessibility is not a challenge.

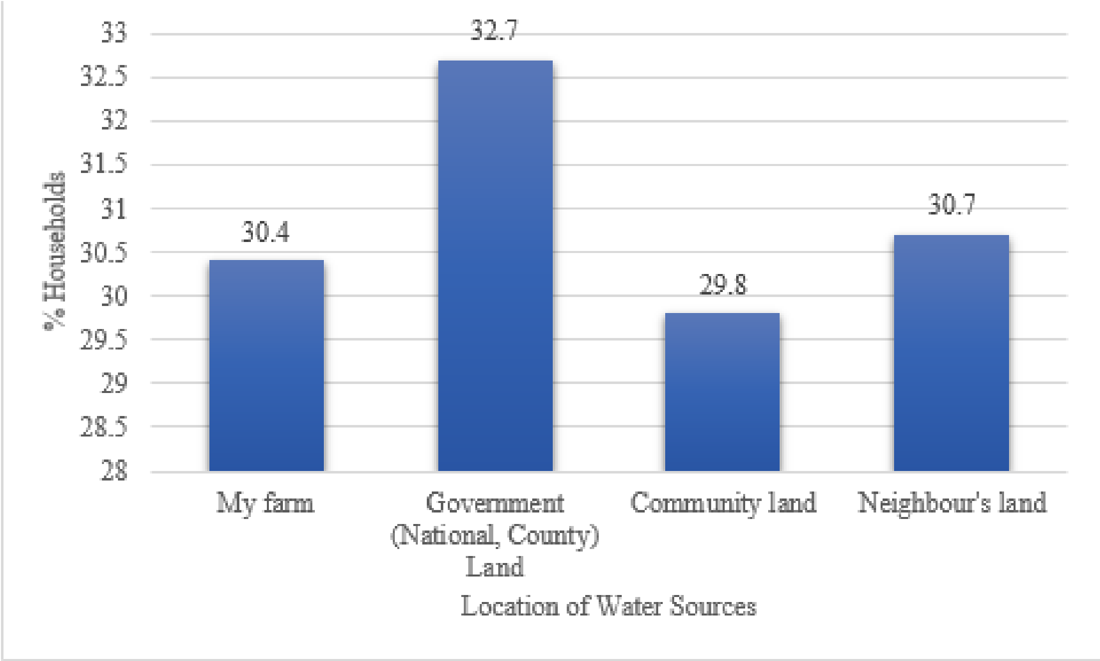

Figure 7: Location of the Water Sources

The study also established that the households use water for various purposes (Figure 8) in decreasing order as follows; washing (99.1%), cooking (96.3%), watering livestock (93.4%, bathing (66.2%), irrigation (42.4%) and lastly drinking (7.4%).

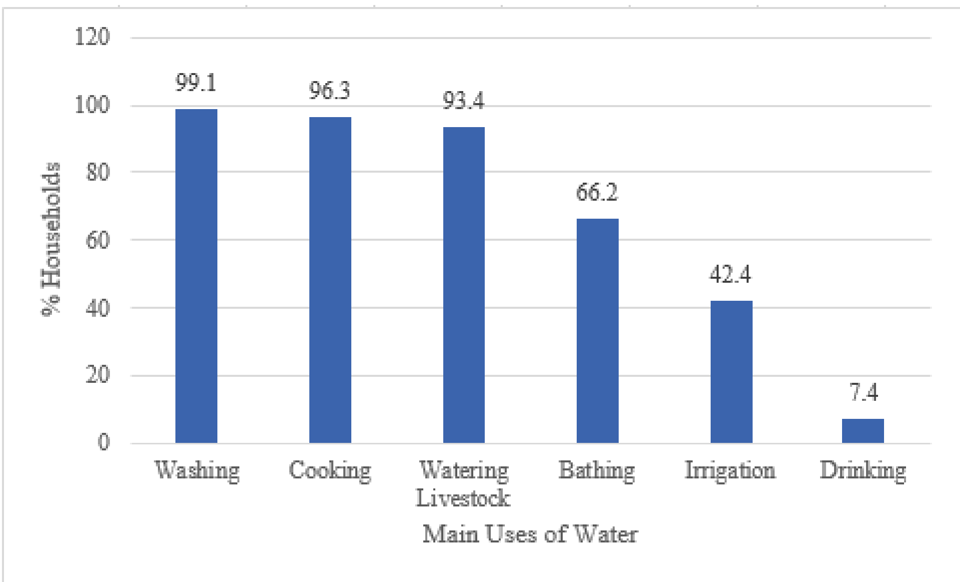

Figure 8: Main Uses of Water

The results are consistent with those of Nyakundi *et al.*, (2010) who also established that households in the study area have multiple uses of water even though only a low percentage of households use the waters for drinking because waters from rivers/streams which are the most popular are on record as not being portable. The water quality in rivers and streams is vulnerable to the effects of drought and or floods. Figure 9 shows the major pollutants for water sources and how the households perceive them. Out of 349 respondents 253 cited human activities such as cooking, washing, bathing and defecating as a major source of pollutant to the water bodies. This was followed by livestock waste (253), farming activities, (100), soil/debris (79) and industrial effluents (79). Plastics and polythene bags recorded very low frequencies (8) just as siltation (9). This is not surprising since use of plastic bags was banned in Kenya from 2018. Besides, in the rural areas, plastic is a gem which when completely worn out due to repeated use, is used as fuel for cooking. Surprisingly siltation is not considered a major pollutant probably due to the fact that silt settles at the bottom. The high frequencies of pollutants reported for livestock waste, farming activities and human activities point to lack of awareness of the people on the consequences of their activities to water.

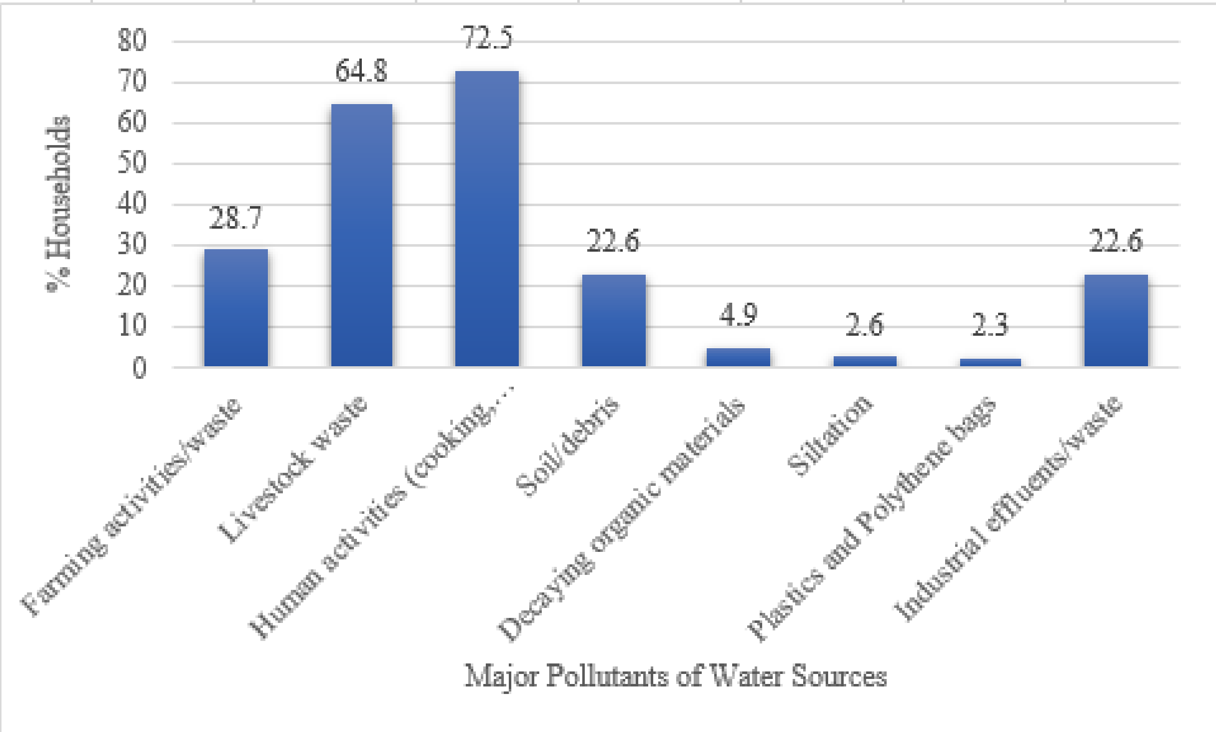

Figure 9: Major Pollutants of Water sources

Selected impacts of floods on water sources were identified. The extent to which each variable is affected by floods was weighted on a scale of 1-5 denoting: No extent, little extent, moderate extent, large extent and very large extent respectively. The impacts selected included turbidity, solid waste contamination (rubbish/debris), contamination with fertilizers and pesticides residues from farming activities, industrial effluents pollution, surface water contamination, ground water contamination, algal blooms, changes of taste of water, contamination by sewerage and siltation. Some of the effects of floods on water Sources are displayed in Plate 3.

Plate 3: Impacts of Floods on Water Sources

The mean of the impact on each variable was then calculated and the average means derived to form the Impact of floods on water sources Index (Table 10). The index refers to the cumulative impacts of floods on water sources. The threshold for high impact is M≥3.0.

Table 10: Impact of Floods on Water Sources Index

Effect	n	Mean	SD
Turbidity	333	4.34	1.04
Solid waste contamination (Rubbish/debris)	331	3.93	1.15
Contamination with fertilizer/pesticide residues from farming activities	333	2.77	1.40
Industrial effluents pollution	332	2.33	1.50
Surface water contamination	331	3.69	1.12
Ground water contamination	331	2.94	1.36
Algal blooms	332	2.94	1.46
Change in taste of water	331	3.06	1.36

Contamination by sewage	332	2.33	1.37
Siltation	312	3.66	1.38
Impact of floods on water sources index	**333**	**3.16**	**0.73**

The impact of floods on water sources (M=3.16) is above the threshold (M=3.0). The relatively low rating for industrial effluents pollution (M=2.33) could be due to inability of the respondents to decipher the pollutant since these would need some sort of analysis or physical witness of the contaminants that enter the water. The low rating (M<3.00) of contamination by sewage, contamination with fertilizer/pesticides and industrial effluents, may be an indicator of the ignorance of the community of the levels of contamination due to the fact that laboratory analysis is off the reach of the individuals and so they cannot perceive the extent of the effects of the chemicals. An example of this would be the low rating of contamination by sewage contrary to the informed opinion and records by the Public Health officer (PHO) at Ahero Health Center of increased incidences of water contamination by E.Coli during the rainy seasons. Nyakundi *et al.,* (2010) reported similar findings, where incidences of water borne diseases increased as a result of floods. KCIDP 2013-2017 also highlighted the increased risk of waterborne diseases as a result of floods, which destroy sanitation facilities in Kisumu County. Barnwell, Rutherford, Mackey, Street and Chu (2018) report that climate change can result in both direct and indirect health impacts. Indirect health impacts of climate change occur as a result of impacts of climate change on secondary factors, which in turn result in health impacts. These indirect impacts occur through two processes mediated by ecosystems and/or human systems as reiterated by Barnwell, Rutherford, Mackey, Street, and Chu, (2018). Ecosystems mediate health impacts of climate change through alterations in characteristics of vegetation, soil, baseline air and water quality, as well as ecosystems services (IPPC, 2014). Besides changes in disease vector distribution and life cycle, water and food-borne diseases are also health impacts mediated by ecosystems (IPPC, 2014). Climate change being a driver for climate-sensitive health hazards (Barnwell *et al.,* 2018), the impact of these hazards with respect to the exposure and vulnerability of a community can result in climate-sensitive disasters.

The ratings for turbidity were the highest and this could be due to the fact that when water changes its color due to turbidity, it is apparent to all and it necessitates some sort of filtration or purification to make it usable. The attributes of water that can be perceived by the sensory organs were ranked highly since the evidence is very clear to the respondents. Cardoso *et al.,* (2013) also reported siltation, changes in taste of water, surface water contamination, and contaminations by solid wastes as impacts of floods on water sources. Similar observation were made during the great Midwestern flood of 1993 along lower Illinois River, where it was reported that floodwaters transported huge amounts of sediment and dissolved pollutants contributed by agricultural watersheds (Ray *et al.*, 1998).

In this study, the overall impact of floods on water sources index was relatively lower (M=3.16 in Table 10) than the impact of floods on soils index (M=3.52 in Table 9). This suggests that floods impact on the soils more than on the water sources and could be a pointer of the limitation of mitigation measures on soils. In all the cases however, appropriate coping strategies were engaged. The severity of impacts depends on the source of pollutants, the level of preparedness to deal with the impacts and technical support. In summary, the impacts of floods on water sources are many and can be lumped together in order of prevalence as follows: Turbidity, Physical, chemical and biological contamination by effluents from farms, industries and sewage and last but not least siltation.

Impacts of Drought on Soils

Information was sought on whether the respondents experience drought and the results indicate that all the respondents have experienced drought. The frequency of drought experienced in a given year was then determined. Most respondents (32.2%) reported experiencing drought at least once a year and only 14.2% reported experiencing drought only once in the last five years (Figure 10) The results also indicate that at least 65.3% of the respondents experienced drought in the last one and a half years. This means that drought is a common phenomenon in the study area.

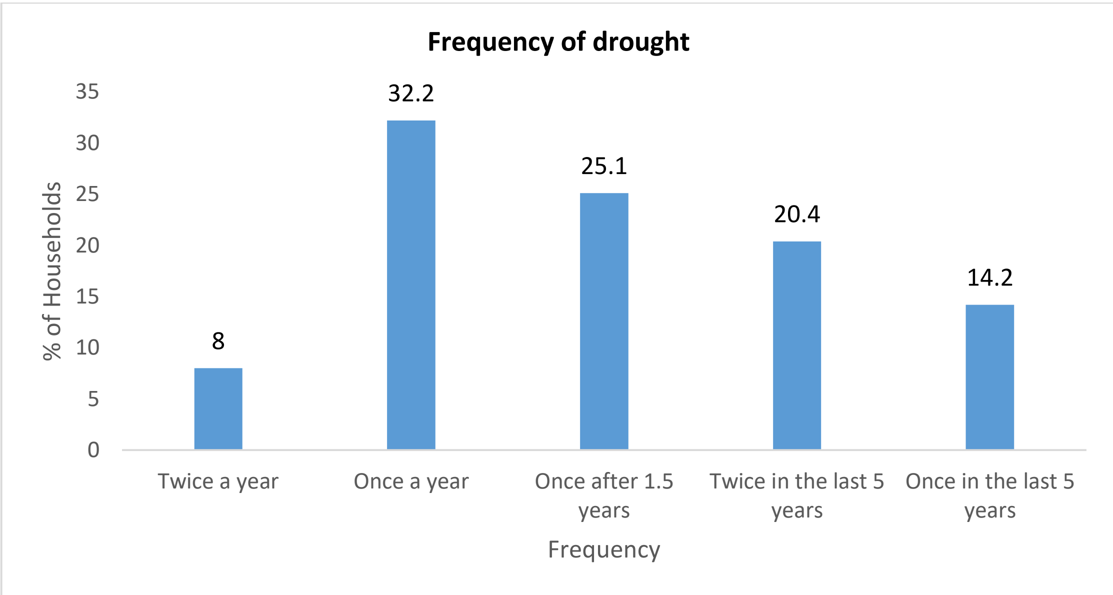

Figure 10: Frequency of Drought Over the Last Five Years

Selected impacts of drought on soils derived from literature were then examined. These were also observed physically in the study area (Plate 4). The extent of the effect of each variable selected was weighted on a scale of 1-5 denoting: No extent, little extent, moderate extent, large extent and very large extent respectively. The effects included soil erosion (by wind), reduced soil productivity, cracked soils, dust bowls, emergence of invasive species, compaction of soils, loss of vegetation cover and loss of soil moisture. The mean of each effect was then calculated and the average means derived to form the Impact of drought on soils Index (Table 11). The index refers to the cumulative impacts of drought on soils in the study area.

The threshold for high impact is M=3.0. From the results in Table 11, all the impacts recorded above average values (M≥3.0) save for emergence of invasive species. Bowl dust posted the highest mean (M=4.46) followed by cracked soils (M=4.44) and loss of soil moisture (M=4.38). This is consistent with findings by other studies such as Mardy, Mohammed, Asaduzzaman, Debashis, Roy and Emily, Shea and Dunn (2018) and Makoti and Waswa (2015) who also reported reduced soil moisture and water scarcity as one of the greatest impacts of drought to farmers.

Table 11: Impact of Drought on Soils Index

Effect	**N**	**Mean**	**SD**
Soil erosion (by wind)	342	3.87	1.27
Reduced soil productivity/	342	4.01	1.02
Cracked soils	341	4.44	0.91
Lots of dust generated by loose soils (bowl dust)	340	4.46	0.80
Emergence of invasive species	340	2.69	1.42
Compacting of the soil	340	4.25	0.93
Loss of vegetation cover	339	4.25	0.97
Loss of soil moisture	339	4.38	0.84
Impact of drought on soil index	**342**	**4.03**	**0.60**

Emergence of invasive species posted the lowest value (M=2.69). Fields covered by cactus species, a sign of degraded soils were also observed in certain sites (Plate 4). Some elderly respondents confirmed that this species has emerged and is taking over bare lands vigorously in the recent past. The cactus species was prevalent in in Nyakach area unlike the other effects, which were widespread. According to Witt, Beale and van Wilgen, (2018) land degradation or disturbances are among the main drivers of plant invasions. Soil cracking (Plate 4) also recorded a high mean of 4.4. This kind of impact was also reported in Iowa following the drought of 2012, where changes in soil structure included fracturing and cracking of the upper 15 to 30 cm (6 to 15 in) of soil or deeper and this resulted in unfavorable conditions for plant development and growth (Al-Kaisi, Elmore, Guzman, Hanna, Hart, Helmers and John (2013). Persistent drought that leads to cracked soils, which later transform into gullies when the flash floods come has also been experienced in Baringo County in Kenya. Such soils end up being poor and cannot support much plant growth (NCCRS, 2010). From the results of this study, the overall mean Impact of drought on soils is quite high standing at M=4.03 on a scale of 1-5. This paints a picture of soils that are under high pressure due to drought in the study area. In summary, the impacts of drought on soils are many and severe and can be lumped together in order of prevalence as follows: Poor soil texture and consistency, loss of soil moisture, loss of soil fertility, soil erosion and emergence of invasive species that thrive in degraded soils. Plate 4 shows land degradation due to a combination of floods and drought.

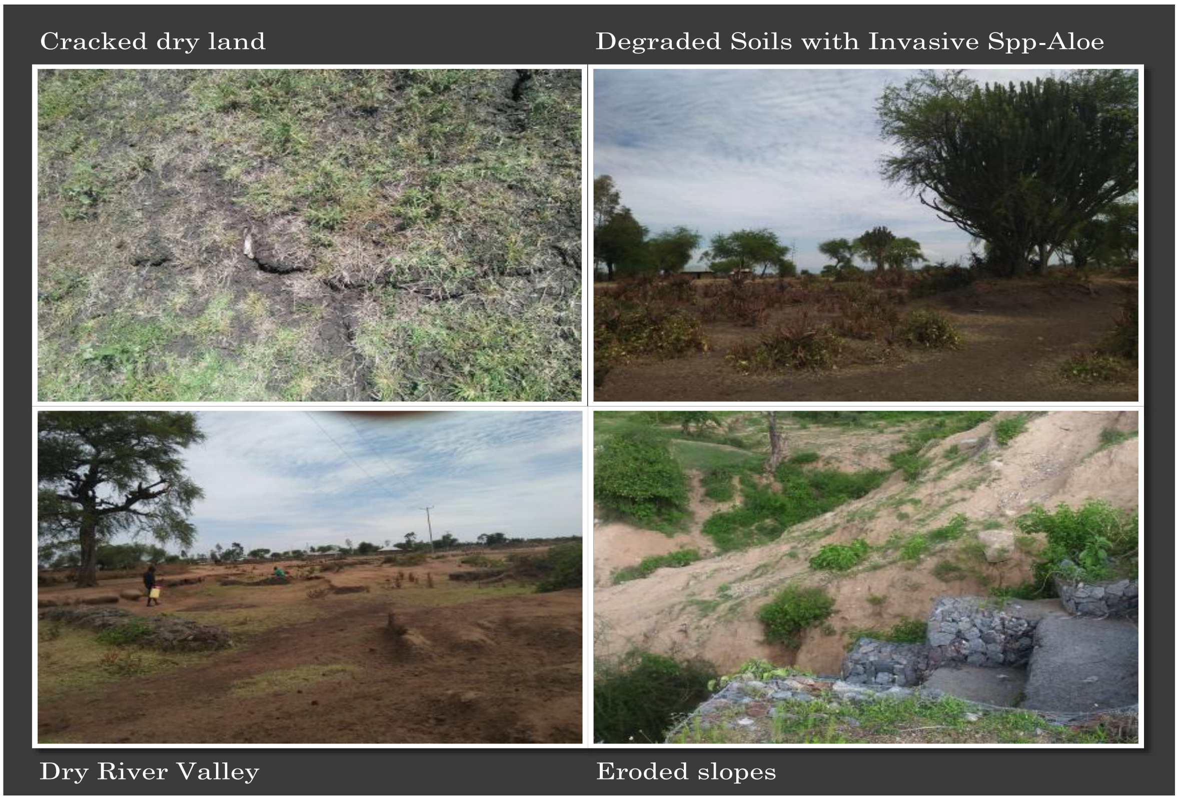

Plate 4: Land Degradation due to Floods and Drought on Soils

Impacts of Drought on Water Sources

Information was sought on whether the water sources are affected by drought. 97.4% responded in the affirmative with only 2.6 % reporting experiencing no effects at all.

The highest impact of drought on water sources was reduced water levels/drying up of water sources (87.1%), followed by contamination (dirty waters) at 25.2%, foul smells (11.4%), change in water colour (6.6%), siltation (2.6%), hardening of water (1.7%) and lastly algal blooms (0.6%)as displayed in Figure 11.

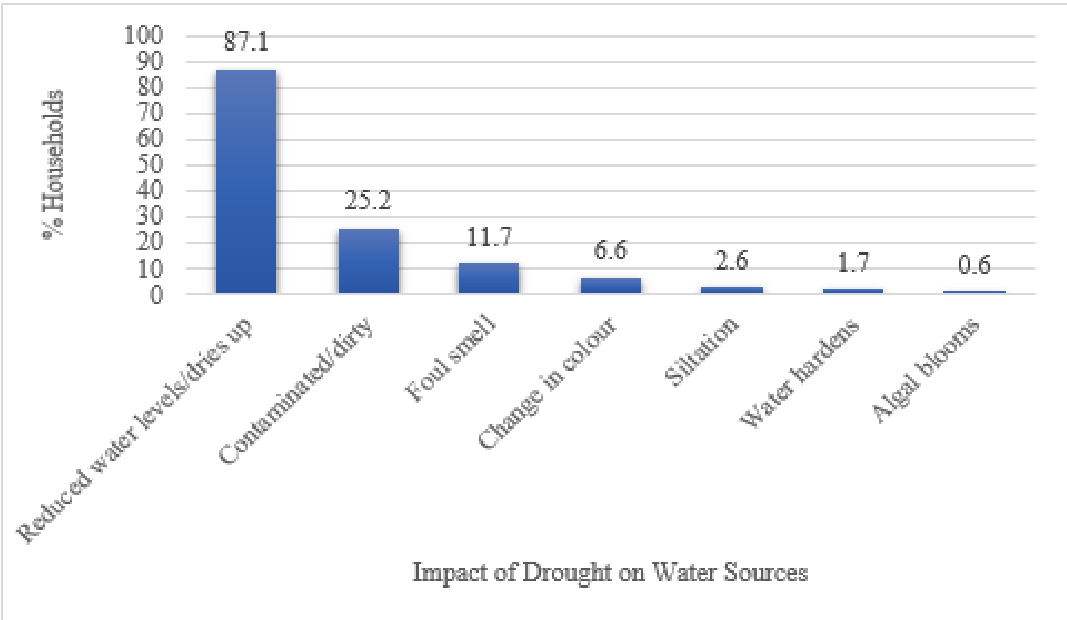

Figure 11: Impact of Drought on Water Sources

Selected effects of drought on water sources were examined. The extent of effect of each variable was weighted on a scale of 1-5 denoting: No extent, little extent, moderate extent, large extent and very large extent respectively. The effects included Pollution, turbidity, reduced water volumes, drying water pans, drying river valleys, drying wells, lowered water table, loss of riparian vegetation and foul smelling waters. The mean of each effect was then calculated and the average means derived to form the Impact of floods on water sources Index (Table 12). The index refers to the cumulative effect of drought on water sources. The threshold for high impact is M≥3.0.

Table 12: Impact of Drought on Water Sources Index

Impact	N	Mean	SD
Pollution (dust, dry objects e.tc)	334	3.45	1.32
Turbidity	334	3.15	1.36
Reduced Water volumes in rivers, lakes, water pans, dams	333	3.95	0.84
Dry water pans	324	3.93	0.93
Dry river valleys	330	3.76	1.05
Dry wells	333	3.47	1.11
Lowered water table	330	3.55	1.11
Loss of riparian vegetation	332	3.38	1.22
Foul smelling waters	333	2.90	1.41
Impact of drought on water sources index	**334**	**3.47**	**0.74**

The results in Table 12 show that the Impact of drought on water sources index was M=3.47. All the variables recorded above average means i.e. M≥3.0except foul smell (M=2.90) indicating the large extent of impacts of drought on water sources. Of significance is the reduced water volume pointing to scarcity of water and unavailability of portable water. These results are consistent with those reported by Ajuang *et al.*, (2016) in Upper Nyakach. Where 86.7% of households reported having observed changes in water sources ranging from drying up to reduction in water quality. According to (Ongwenyi *et al.*, 1993), when the hydrology of a place with decreasing rainfall, surface runoff becomes sparse, sub surface water is not recharged and the local aquifers become dry. This is evident in the high mean for lowered water table, loss of riparian vegetation, dry wells, dry river valleys and reduced water volumes in rivers (Table 12). When Rahman, Ahmed and Islam (2016), modeled climate-induced droughts in the north-west region of Bangladesh using quantitative trend analysis of secondary data of temperature, rainfall, relative humidity, and ground and surface water, they found out that changing climatic indicators and surface water availability affected the groundwater level and, subsequently, triggered droughts.

In another study conducted in the lower river Tana catchment, livestock concentrated near reliable water source such as boreholes, which were already under grazing pressure during drought (Ongwenyi, Denga, Abwao and Kitheka, 1993). This was an indicator that their usual water sources had dried up. Similar trends are seen in the study area where during drought, livestock troop to the wetlands for grazing and water, a practice which even though is a coping mechanism, is counterproductive on the wetlands, which are already under severe threat (Raburu *et al.,* 2012). In summary, the impacts of drought on water sources are many and severe and can be lumped together in order of prevalence as follows: reduced water volumes hence water scarcity, water pollution by dust, and debris and loss of water quality leading to turbidity and foul smells. All these render the water not fit for human consumption.

Impact of CCRDs on the Environment

In order to determine the Impact of CCRDs on the environment, the means of Impact of floods on soil, Impact of floods on water sources, Impact of drought on soils and Impact of drought on water sources was computed to give a composite index (Table 13). This index represents the cumulative effects of CCRDs on the environment referred to as Impact of CCRDs on the environment. The threshold for high impact is M≥3.0.

Table 13: Impact of CCRDs on the Environment Index

Scale	n	Mean	SD
Impact of floods on soil	343	3.52	0.75
Impact of floods on water sources	333	3.16	0.73
Impact of drought on soil	342	4.03	0.60
Impact of drought on water sources	334	3.47	0.74
Impact of CCRDs on the environment index	**346**	**3.47**	**0.60**

From the results (Table 13), the Impact of CCRDs on the environment is M=3.47 which is way above the average M≥3.0. This shows that the Impact of CCRDs on the environment is weighty (a large extent). The scale of damage by a flood and by extension, drought event largely depends on the state of preparedness and response mechanisms employed by the communities affected to combat the negative impact (Nyakundi, 2010). The high impact of CCRDs on the environment in this study points to the level of preparedness and the response mechanisms engaged. This will be explored in the results addressing objective 3 in this study. The high impact recorded in this study has potential to impact the agriculture sector, livelihoods and social setups (Opondo, 2013), which largely depend on the environment for survival. All the three divisions recorded means greater than the threshold (M>3) implying that CCRDs is widespread in the area (Table 14).

Table 14: Means and Standard Deviations of Impact of CCRDs on the Environment by Division

Division	n	Means	SD
Kadibo	109	3.55	0.63
Nyando	197	3.44	0.59
Lower Nyakach	40	3.37	0.59

Table 14 shows that the means (M=3.55, SD= .63) of Kadibo was highest followed by those of Nyando (M=3.44) and Lower Nyakach (M=3.37). An examination of these results shows that they are comparable suggesting that the differences among the means were not statistically significant. The decision to accept or reject the hypothesis which states that there is no significant differences in Impact of CCRDs on the environment among the three divisions could not be made on the basis of these results only. This decision was made based on the results of the ANOVA test. The results of this test are in Table 15.

Table 15: Comparison of Impact of CCRDs on the Environment by Division Using ANOVA Test

Scale	Sum of Squares	df	Mean Square	F-ratio	p-value
Between Groups	1.345	2	.672	1.873	.155
Within Groups	123.134	343	.359		
Total	124.479	345			

The results indicate that the difference in Impact among households heads from Kadibo, Nyando and Lower Nyakach were not statistically significant at the .05 level, $F(2, 343) = 1.873$, $p = .155$. This means that the Impact of CCRDs on the environment of households were similar in the three divisions. These results support the hypothesis, which states that there is no significant in Impact of CCRDs on the environment of households among the three divisions. This hypothesis was accepted on the basis of these results.

This could be attributed to their geographic allocation, which predisposes them to similar climatic conditions and vulnerability to secondary effects of land use upstream. None of the household heads pointed out bacterial contamination of water sources and soils as a consequence of CCRDs on the environment, yet the key informants, in the study area noted that floods cause infestation of soils with Coliform bacteria and E.Coli due to fecal contamination. This can be linked to the collapse of pit latrines collapse, which happens during floods (Nyakundi *et al*., 2010). The Key informant (Medical Health Officer) reported a lot of ignorance of soil infestation by worms due to open defecation that is prevalent when floods wash away latrines. Organic wastes from human body can be used to generate biogas and the residual solid matter which good fertilizer for agriculture would be used on the farms (Regattieri, Bortolini, Ferrari, Gamberi and Piana, 2018), However socio-cultural barriers discourage use of biogas for fuel (Smith et al, 2012), yet proper management of fecal waste could alleviate the Health risks and diseases associated with improper management of human wastes. Harvey, Baghri and Reed (2011) reiterate that if waste is managed properly, then the waterways and water sources can be kept clean and free of bacterial contamination. The same source reported high incidences of E.Coli during the April-May floods of 2018 to the extent that some schools near River Nyando like Ahero Girls and St. Annes Girls secondary schools were ordered closed by the Provincial Health Department (PHD) to avert an epidemic. This source further reported that only 11 water supply systems are functional in Nyando and that their level of contamination both bacteriologically and chemically was about 51%. This implies that the water sources are not safe and efforts to decontaminate them need to be intensified. The most susceptible to contamination are the wells (Thorlakson and Neufeldt, 2012). In the study area, the PHD supply chemicals for treating water though the quantities are inadequate. Community Health Volunteers (CHV) also chlorinate the shallow wells but this too is limited to the wide area affected by floods. Households are therefore encouraged to disinfect their water and factor in the cost of purchasing chemical disinfectants in their monthly budgets.

The Key informants who are directly in charge of the natural resources by virtue of their jobs and assignments decried the poor resource allocation and facilitation accorded the extension officers by the County government. Seemingly the transition authority following the promulgation of the Kenya constitution 2013, did not exhaustively address the creation of proper management and service delivery structures such that money flow from the national governments is not cascaded to the Counties and sub-Counties. In the study area, politics affect resource allocation to the extent that each Member of the County Assembly (MCA) initiates development projects in their wards instead of prioritizing the needs of the Sub-county. This leads to incomplete projects and poorly implemented work plans due to lack of synergy. If resource allocation was prioritized and focused to mitigate the effects of CCRDs on the environment, probably the Impact Index would be lower and the households would be less vulnerable. From the above analyses, it can be concluded that CCRDs affect the study area in equal measures. Subsequently, the interventions should take a landscape approach starting from the highlands whose activities set the tempo of CCRDs experienced in the Nyando River Basin (Okayo *et al.*, 2015). The degree of impact of extreme climate events such as floods and drought also depends on the resistance and resilience of the affected communities (Opere, 2013). The high Impact index of 3.47 (Table 13) therefore points to weak resilience of the households in the study area.

4.5 Objective 2: Resilience of Households to Impact of CCRDs

Objective 2 sought to determine the resilience of households in lower Nyando River Basin of Kisumu County to Impact of CCRDs on the environment. The indicators of resilience were households' ability to cope and recover from impacts of CCRDs. These were decomposed into various variables that were measurable. The outcome was a resilience index. In order to determine this, a questionnaire (Appendix 1) and Key informants guide (Appendix 3) were used to generate information on how households cope with and recover from impacts of floods on soils, impacts of floods on water sources, impacts of drought on soils and impacts of drought on water sources. Selected variables were used as the key indicators of coping and recovery from impacts of CCRDS on soils and water sources. These generated coping and recovery indices, which were then used to derive the resilience index.

4.5.1 Coping

Coping as an attribute was measured to determine resilience of households to impacts of CCRDs on the environment. In order to determine this, information was sought on the use of various selected coping mechanisms to deal with impacts of floods and drought on soils and water sources using a household questionnaire (Appendix 1) and Key informant's guide (Appendix 3). This generated a mean referred to as the coping index.

Coping With Impacts of Floods on Soils

The household heads were asked if they engage in any activities that enable them cope with floods. 94.7% acknowledged that they do against 5.3% only who do not. Further the respondents were asked to state how frequently they engage in a total of nine selected activities commonly used to address effects of floods on soils. (Appendix 1 and Appendix 3). The activities included use of sand bags, digging terraces to drain off excess water, clearing water channels, building gabions, contour ploughing, construction of check dams and ponds, intercropping and agroforestry. The frequency of engagement in each activity to cope with effects on floods on soils was weighted on a scale of 1-5 denoting: never, rarely, occasionally, and often and very often respectively. The mean of the frequencies for each activity was generated. These means were then computed to arrive at a final mean (M) referred to as the coping with Impact of floods on soil index (Table 16). $M \geq 3$ was considered high whereas those below three ($M<3$) were considered low.

Table 16: Coping With Impacts of Floods on Soils Index

Coping activity	N	Mean	SD
Use sand bags	323	3.30	1.41
Use organic manure/compost	325	2.80	1.43
Dig terraces to drain off excess water	322	3.93	1.24
Clearing water channels	327	3.57	1.38
Build gabions	326	2.25	1.36
Contour Ploughing	325	2.80	1.52
Construct check dams and ponds	324	2.73	1.51
Intercropping (trees and crops)	323	2.75	1.58
Planting trees on degraded soils	320	3.00	1.51
Coping with effect of floods on soils index	**327**	**2.98**	**0.94**

From the results in Table 16, the index for coping with floods on soils was M=2.98. This figure is on the borderline and points to the adequacy of the mitigation measures taken to mitigate effect of floods on soils. Digging terraces to drain off excess water seems to be the most frequently engaged mechanism followed by use of sandbags, and draining water channels. This could be attributed to the fact that the occupation of majority of people is subsistence farming (Nyakundi *et al.*, 2010), and therefore most households own farm implements like machetes and slashers, which are the implements used for farming, and which they can utilize to drain off excess water. The sand bags are also popular just like was the case in flood prone settlements in Tanzania (Sakijege, 2012) Interventions that constitute Conservation Agriculture (CA) e.g. use of organic manure, contour ploughing and intercropping (Michura, 2016) seem not to be applied very frequently. This could be due to lack of knowledge on the benefits of CA due to poor extension services, a problem that the key informants highlighted as being chronic. According to Michura (2016), knowledge of the environment and climate change significantly influences farmers' adoption of CA.

Planting trees on degraded lands scored highly (M=3.0) compared to intercropping (M=2.75). The rationale could be that degraded lands are better rehabilitated by afforestation (Ngaira and Musiambo, 2012), which would be more beneficial in the long run than practicing agriculture on degraded soils. Furthermore, intercropping (trees with crops) is least favored because the trees shade the crops leading to poor harvests besides the long wait required before the benefits of trees is realized (Thorlakson, 2011) It also emerged that interventions that are more labor and capital intensive like building gabions (Plate 5) and construction of check dams and ponds are not very often applied. These interventions require collective effort and proper organization of community members, a scenario best achieved through coordination by NGOs like VIRED and World Vision, which operate in the area to support such initiatives. Therefore at the household level, respondents would not have rated it highly as an individual initiative. Overall the results point to average coping capacity of households. Coping capacity relates to the factors influencing the ability of a community to prepare for, absorb and recover from a natural hazard event (Parsons *et al.*, 2016). The knowledge, skills and materials at the disposal of the households therefore shape the coping behavior. As such the communities need to be empowered with information, organization skills, attitudes and materials that can help them cope.

Coping With Effects of Floods on Water sources

The household heads were asked to state how frequently they engage in a total of nine selected activities commonly used to address effects of floods on water sources and hence referred to as key indicators in this study. The activities included: use of water filters to remove silt, decontaminating drinking water (using water guard). Treating water in boreholes and wells, building toilets well raised above the ground level, protecting/securing drinking water collection points, sealing wells to avoid contamination, wetland plants regeneration, spring head protection, not encroaching into riparian land, use of sand bags at river banks to prevent soil erosion and training on disaster preparedness and management. Some of the coping mechanisms observed are displayed in Plate 5.

Plate 5: Mechanisms for Coping With Impacts of Floods on Water Sources

The frequency of engagement in each activity to cope with effects on floods on water sources was weighted on a scale of 1-5 denoting: never, rarely, occasionally, and often and very often respectively. The mean of the frequencies for each activity was generated. These means were then computed to arrive at a final mean referred to as the coping with the effects of floods on water sources index (Table 4.12). $M \geq 3$ was considered high whereas those below three ($M < 3$) were considered low.

Table 17: Coping With Effects of Floods on Water Sources Index

Activity	**N**	**Mean**	**SD**
Use water filters to remove the silt	322	3.48	1.42
Decontaminate drinking water	322	4.14	1.12
Treat water in boreholes and wells	322	2.91	1.66
Build toilets well raised above the ground level	323	2.71	1.42
Protect /secure drinking water collection points	323	3.55	1.39
Seal wells to avoid contamination	321	3.54	1.39
Regenerate wetland plants	321	3.08	1.56
Spring head protection	317	2.30	1.39
Not encroaching into the riparian land (30m from the highest water mark)	322	2.59	1.38
Use sand bags at river banks to prevent soil erosion	319	3.12	1.54
Training on disaster management-preparedness	322	1.89	1.06
Coping with effects of floods on water sources index	**323**	**3.01**	**0.81**

From the results (Table 17), most households engage multiple coping mechanisms. Adopting more than one coping mechanism is common with most households affected by floods (Opondo, 2013). Most of the interventions which can be undertaken at individual level for instance, the use of water filters, decontamination of drinking water and securing drinking water collection points (wells) scored highly M≥3.0 compared to those that require collective action e.g. spring head protection and observing the riparian land boundaries (M<3.0). Seemingly people are keen on interventions that would guarantee their immediate wellbeing compared to those interventions whose benefits is long term and spread out to the larger community. Similar results were recorded by Béné *et al.*, (2016), who found out that wellbeing is subjectively constructed and it greatly influences individuals' choices and investment in coping mechanisms. Building raised toilets that cannot be swept away by floods ranked third lowest just after training and spring head protection. It is not surprising considering that human behavior follows Maslow's' hierarchy of needs theory, where physiological needs fulfill deficiencies e.g. hunger and shelter followed by growth needs. People would therefore give priority to food, clean water, air and sleep (shelter) before seeking safety and security.

The mean index for coping with floods on water sources was M=3.01. On a scale of 1-5, this is above average despite training on disaster management/preparedness posting the lowest mean (M=1.89). The findings corroborate the Key informants who highlighted the limited training offered to communities and were of the opinion that training should happen even before disasters as opposed to the current scenario where training if it happens, is post-disaster. This shows that the communities have learnt to use resources at their disposal i.e. skills, knowledge and even their resources to deal with changes in their environment (Imperiale and Vanclay, 2016). This could be attributed to cumulative knowledge of dealing with effects of drought on water sources out of experience. The results compare with those of Kgosietsile, Nthalivo, and Mphemelang, (2018) who established that small scale farmers in Northern Botswana have developed place-based coping strategies to cushion and sustain their livelihoods against the impacts of Climate change based on their live experiences. They concluded that there is need for place-based education to develop, highlight and strengthen the knowledge of space lived experiences. Therefore there is need to enhance training on disaster management in order to share new knowledge and skills in this field. Once people pass through the immediate disaster, they tend to forget and consequently with each new cycle of disasters, they plough more and more resources in dealing with the same issues. The need for continuous training cannot be belabored on. Encroachments on riparian land scored low implying people do not observe the environmental laws on no cultivation on riparian land. Law enforcement needs to be enhanced to deter non–conformity with consequent protection of water resources.

Coping With Impacts of Drought on Soils

The household head were asked if they engage in activities that enable them cope with drought. 94.7% acknowledged that they do against 5.3% only who do not. They were then asked to state how frequently they engage in a total of ten selected activities commonly used to address effects of drought on soils, which were considered as the key indicators in this study. The activities included: mulching, irrigation, control free range grazing, paddocking, movement to wetlands to plough there, plough soils to break the hard pans, plant cover crops, agroforestry, planting drought resistant crop varieties. The frequency of engagement in each activity to cope with effects on drought on soils was weighted on a scale of 1-5 denoting: never, rarely, occasionally, and often and very often respectively. The mean (M) of the frequencies for each activity was generated. These means were then computed to arrive at a final mean referred to as the coping with impact of drought on soils index (Table 18). $M \geq 3$ was considered high whereas those below three ($M<3$) were considered low.

Table 18: Coping With Impacts of Drought on Soils Index

Activity	N	Mean	SD
Mulching	325	2.31	1.41
Irrigation	326	2.74	1.51
Control free-range grazing/free grazing	326	2.87	1.43
Paddocking (controlled grazing)	325	2.07	1.30
Move to the wetlands to plough there	324	2.96	1.49
Plough soil to break the hard pans and allow decomposition of weeds and plant debris accelerated by high temperatures	324	3.68	1.37
Plant cover crops	321	3.20	1.45
Agro-forestry and planting hedges around the homestead	321	3.14	1.50
Plant cover crops	305	3.16	1.42
Planting drought resistant crop varieties e.g. cassavas, pigeon peas etc.	318	3.05	1.54
Coping with impacts of drought on soils index	**326**	**2.87**	**1.01**

The results in table 18 show that Paddocking is the least applied intervention (M=2.07) followed by Mulching (M=2.31). The failure to paddock could be as result of limited land. The average land size of 2 acres is close to the mean land holding size in the county (1.6 acres) according to KCIDP (2013-2017) and this is intensively used for subsistence and economic purposes. Due to population pressure the same parcels of land continue to be subdivided into uneconomical sizes making practices like paddocking impractical. Mulching is also rarely used probably due to lack of vegetation during the dry season as revealed by this study. Ploughing

(M=3.68) is the most used intervention following traditional practices of land management as opposed to Conservation Agriculture (CA) advocated for (Michura, 2016). The key informants also reported the same and suggested the adoption of conservation agriculture practices to mitigate the effects of drought on soils. Controlling free grazing scored a mean of 2.87. This low score can be explained by the fact that in this community, during drought, the vegetation cover is sparse and hence most animals are moved to the wetlands for grazing (Raburu *et al.,* 2012). Planting drought resistant crops seemed popular as an adaptation strategy. Similar results were reported by Mutekwa, (2009) who found out that small scale farmers in Zimbabwe shifted to drought resistant crops such as sorghum, and finger millet to circumvent the challenges posed by high frequency of mid-season dry spells and shortening rainy seasons. Agroforestry and planting hedges around the homestead recorded a high mean of 3.14. This resonates with the findings of Ngaira and Musiambo, (2012) whose study on climate change impacts and mitigations in Africa revealed that trees are planted as fences, hedges and for firewood in homesteads in the Lake Victoria Basin and these also sequester carbon by mopping up the carbon dioxide in the atmosphere and possibly reverse the impacts of climate change caused by deforestation. Overall, the index for coping with drought on soils was 2.87. This index is low implying that mechanism households engage to cope with effects of drought on soils may be inadequate.

Coping With Impacts of Drought on Water Sources

The household heads were asked to state how frequently they engage in a total of nine selected activities commonly used to address effects of drought on water sources and which were considered as the key indicators in this study. These included filtering water, digging sandy beaches for water, restricted grazing in wetlands, dredging wells, deepening the well, restricting abstraction of water, rehabilitation of damaged river banks, widening drainage systems and de-silting drainage systems. The frequency of engagement in each activity to cope with effects of drought on water sources was weighted on a scale of 1-5 denoting: never, rarely, occasionally, and often and very often respectively. The mean (M) of the frequencies for each activity was generated. These means were then computed to arrive at a final mean referred to as the coping with effect of drought on water sources index (Table 19). M≥3 was considered high whereas those below three (M<3) were considered low.

Table 19: Coping With Impacts of Drought on Water Sources Index

Coping strategy	**N**	**Mean**	**SD**
Filter water	324	3.57	1.45
Dig up sandy beaches for water	324	2.44	1.47
Restrict/control grazing in wetlands	323	2.88	1.47
Dredging (cleaning the well)	317	3.33	1.37
Dig the well further-deepen	325	3.40	1.48
Restrict/control abstraction	325	2.81	1.45
Rehabilitate damaged river banks	325	2.90	1.52
Widen drainage system	326	3.14	1.43
De-silt drainage systems	326	3.31	1.38
Coping with impacts of drought on water sources index	**326**	**3.07**	**1.00**

From the results in Table 19, the index for coping with drought on water sources was above average (M=3.07). This can be interpreted to mean that the households are not badly off in terms of knowledge and practice of engaging coping mechanisms to impacts of drought on water sources. Filtering water is the most popular intervention (M=3.57) followed by deepening the well (M=3.40) and dredging wells (M=3.33). All the interventions that reported means (M≥3.0) are interventions that stand to benefit individual households by virtue of ownership or proximity to the water source and where failure to take action would render them more vulnerable as opposed to interventions on communal water sources e.g. and rehabilitating damaged river banks (M=2.90), restricting/controlling abstraction (M=2.81) and restricting grazing in wetland (M=2.88). A possible explanation to this is that individuals perceive common property as the responsibility of everyone and in the absence of proper planning and preparation for disasters as alluded to earlier by the results few people would be moved to protect an asset for the common good. Studies in Nyando show that people tend to respond individually to assure their own safety before they think of their neighbors when faced by disasters (Okayo *et al*., 2015). Households also lack confidence to rely on cooperative solutions or to depend on local government units for defensive mechanisms and hence they resort to interventions that are affordable at the household level (Masese *et al.*, 2016). Considering that drought is a slow onset disaster (OCHA, 2011) and the skepticism that climate variability in the area portends (Nyakundi *et al.*, 2010), people in the study area are reluctant to invest their resources (time, energy and equipment) in preparing common assets like riverbanks, wetlands and restricting abstraction from sandy beaches. Therefore education on the values and functions of natural capital whether personal or communal should be a priority (Thorlakson, 2011). Other studies have also proved that both individual and collective adaptations are essential in building resilience to change (Lereboullet, Beltrando and Bardsley, 2013). Therefore, Policy aimed at mainstreaming adaptation to CC and resilience should address immediate benefits at household level first then buy into community goodwill to embrace Interventions that would benefit the larger populace.

Coping With Impacts of CCRDs on the Environment Index

In order to get the overall index of coping with CCRD on the Environment, the mean of the four indices generated earlier was derived (Table 20). The threshold for coping required to confer resilience to households is M=3.

Table 20: Coping With Impact of CCRDs on the Environment Index

Scale	n	Mean	SD
Coping with effect of floods on soils index	327	2.98	0.94
Coping with effect of floods on water sources index	323	3.01	0.81
Coping with effect of drought on soils index	326	2.87	1.01
Coping with effect of drought on water sources index	326	3.07	1.00
Coping with Impact of CCRDs on the environment index	**342**	**2.84**	**0.90**

From the results in Table 20, the coping index of households is M=2.84 which is below the threshold to confer resilience. The mean coping value for drought on water sources was highest (M=3.07) followed by that of floods on water sources (M=3.01), floods on soils (M=2.98) and the least was drought on soil (M=2.87). It can also be inferred that coping with impacts of CCRDs on water sources (M=3.07 and M=3.01) is better than coping with impacts of CCRDs on soils (M=2.98 and M=2.87). This implies that the households' options of coping with impacts of CCRDs on water sources are more elaborate or intensive than those for coping with impacts of CCRDs on soils. Extension services targeting soil health therefore need to be intensified. Surprisingly, a respondent in Wawidhi location was of the view that they are better placed to deal with floods than with drought.

"We are used to the floods and have devised ways of coping, but drought is still a mountain to climb". At least with floods, water is there in plenty and food is not scarce but with drought, neither food nor water is available".

Probably the subjective perception that floods are manageable has been reinforced by experience (Parsons *et al.*, 2015) and the short-term gains of cultivating riverbanks are illusionary. Besides, drought unlike floods has not received as much attention in this study area since the magnitude is incomparable to drought incidences that ravage the Arid and Semi-Arid Lands of Kenya. Seemingly, the community is unable to link the deteriorating soils quality (Thorlakson and Neufeldt, 2012) and lower yields to CCRDs. Impacts on soils would also become apparent after many years and the absence of supportive data, correlating the two may not be feasible. The index (M=2.84) reflects the overall capacity of the households to cope with the effects of CCRDs on the environment. From the findings, households engage a portfolio of responses in the face of CCRDs, similar to the findings of Béné *et al.*, (2016). The availability of and capacity to engage a variety of coping options in the face of changes is a positive indicator of moderate resilience. This has been proven to be true from other studies (Masese *et al.*, 2016). However, it will be noted that Soil and water conservation strategies, despite their potential effectiveness in addressing some of the challenges of climate change, require much labor and appropriate training of extension workers and farmers (Mutekwa, 2009). Such expensive and labor-intensive interventions includes, building gabions and irrigation. The effectiveness of the mitigation measures also varies depending on soil and weather conditions as well as according to specific characteristics of the different productive systems (Rojas *et al.*, 2014). In this study, despite the vast area, the coping strategies were not location specific but rather the strategies were uniformly tested across the board with the assumptions that the socio-ecological and production systems are the same. Generally households engage in a plethora of strategies in the face of one particular event just as reported by Béné *et al.*, (2016). The means of Coping with CCRDs amongst the divisions was computed as in Table 21. An ANOVA test showed significant differences across divisions (p = .027) as in Table 22.

Table 21: Means and Standard Deviations of Coping With Impact of CCRDs in the Environment by Division

Division	n	Mean	SD
Kadibo	109	3.03	1.03
Nyando	193	2.76	0.86
Lower Nyakach	40	2.70	0.65

Table 21, shows that the means (M = 3.03, SD = 1.03) of Kadibo was the highest followed by those (M = 2.76, SD = 0.86) of Nyando and Lower Nyakach (M = 2.70, SD = 0.65) respectively. An examination of these results indicates that they were not comparable. The results suggest that the differences among the means were statistically significant. A further interrogation of the results showed to determine significant differences was done using ANOVA. The results of this test are in Table 22.

Table 22: Comparison of Impact of CCRDs on Coping Among Households Heads by Division Using the ANOVA Test

Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Between Groups	5.869	2	2.935	3.643	.027
Within Groups	273.112	339	.806		
Total	278.982	341			

The ANOVA results indicate that the differences in Impact of CCRDs on Coping with Impact of CCRDs on Environment resilience among Household heads from Kadibo, Nyando and Lower Nyakach was statistically significant at the .05 level, $F(2, 339) = 3.643$, $p = .027$. In order to determine where the differences exist in the divisions, pairwise comparison was done (Table 23).

Table 23: Pairwise Comparison of Coping With Impact of CCRDs on the Environment by Division

Pairs	Mean difference	SE	p-value
Kadibo - Nyando	0.27	0.11	.046
Kadibo – Lower Nyakach	0.33	0.17	.143
Nyando - Lower Nyakach	0.06	0.16	.928

From the results in Table 23, Differences between Kadibo – Nyando ($p<.05$) was statistically significant while the differences between Kadibo – Lower Nyakach ($p>.05$) and Nyando – Lower Nyakach were not ($p>.05$). The results show that there is disparity in the ability to apply interventions across the divisions. Efforts need to be made to ensure that location specific interventions are adopted based on the perceptions and ability of the targets to adopt them. The availability and capacity to engage a variety of coping options in the face of changes is a positive indicator of resilience.

4.5.2 Recovery

The other attribute measured to determine resilience of households to impacts of CCRDs on the environment was Recovery. In order to determine this, information was sought on the success levels of the interventions they adopt to restore their soils and water sources as a result of the impacts of floods and droughts (Appendix 1 and Appendix 3). This generated a mean referred to as the Recovery index.

Recovery From Impacts of Floods on Soil Index

Information was sought on whether the respondents undertake interventions to repair their land following floods. 90.3% of the respondents acknowledged doing something to repair damages on their land while 9.7% did nothing to repair damage on their land. Further the respondents were asked to state the interventions they engage to restore the land. Generally they engage a plethora of interventions (Figure 12) some more popular than others. Construction of protective structures (26.9%), planting trees and cover crops (26.6%) were the most popular despite them being long-term remedies. Intercropping, mulching, and contour ploughing recorded lower percentages (6.9%, 3.2% and 2.9% respectively). This points to low adoption of Conservation Agriculture, a practice that should be encouraged for sustainable farming.

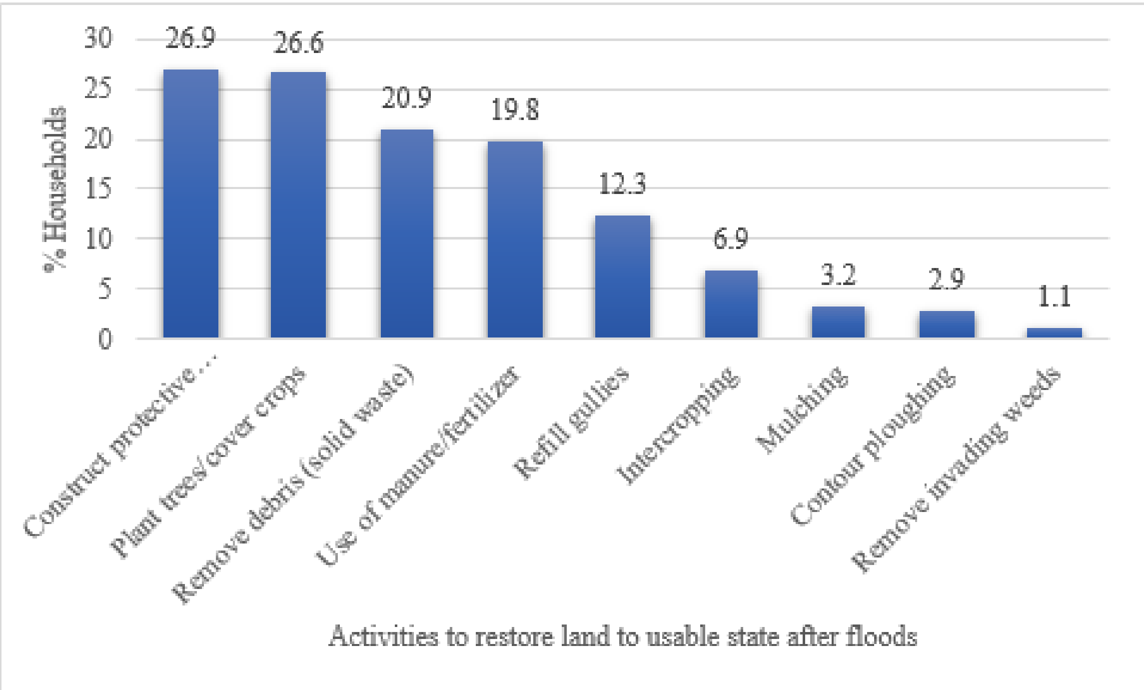

Figure 12: Activities Done to Restore Land to Usable State After Floods

In order to determine recovery, the respondents were asked to state how successful the interventions in Figure 12 were in dealing with the effects of floods on soils. Post disaster recovery was described by the success of interventions taken to repair damages on soils as a result of floods rated on a scale of 1-5 denoting: Never successful, Rarely Successful, Occasionally Successful, Often Successful and always Successful respectively. The mean of the success of each variable was calculated and the composite mean for all the variables derived to yield the Soils recovery index. The results are displayed in table 24. M≥3 was considered high whereas those below three (M<3) were considered low.

From the results in Table 24, the floods soil recovery index (M=1.84) is way below average implying that the interventions chosen are never successful. The poor levels of success could be due to the inadequacy of the interventions taken especially given that they are done on autonomously (Byamukama *et al.*, 2011). Furthermore, the frequency

Table 24: Recovery From Impacts of Floods on Soils Index

Recovery	**N**	**Mean**	**SD**
Washed away top soil	314	1.95	1.18
Solid waste contamination (mud and debris)	313	1.92	1.22
Contamination with fertilizer and pesticide residues	306	1.71	1.04
Gullies created by floods	315	1.76	1.13
Leached nutrients in the soil	309	1.84	1.12
Eroded vegetation cover	312	1.85	1.12
Invasive species (e.g. striga)	304	1.79	1.07
Water logging	309	2.08	1.28
Soil and sediment contamination	304	1.81	1.10
Reduced soils fertility	310	2.05	1.21

Recovery from impacts of floods on soil index	**315**	**1.84**	**0.89**

of floods and drought hardly give room for full recovery of the soils before the effects are experienced once again (Béné *et al.*, 2016). Cumulatively, the impact may worsen over the years. The remedy would probably be to focus on interventions that would avert the progression of Climate change and its consequent Impact. A landscape approach in the application and adoption of interventions like afforestation and conservation Agriculture would suffice. On the other hand, probably the losses due to floods on soils (Impact) could far outweigh the recovery effort to the extent that post disaster recovery is very slow and the next disaster (floods) commences before return to normalcy (Yu *et al.*, 2015). A knowledge gap exists in the study area as to how well the households manage to restore their soils. This study addresses this gap even though the parameters used to measure recovery are not exhaustive. Other scholars used recovery cost (Yu *et al.*, 2015), time taken to recover (Vugrin *et al.*, 2010) and even productivity to measure recovery. Studies on recovery of soils after floods at the community level if any are not documented.

Recovery From Impacts of Floods on Water Sources

Information was sought on whether the respondents undertake interventions to restore the water sources following the effects of floods. 83.2% of the respondents acknowledged doing something to restore the water sources while 16.8% reported doing nothing to repair damage on their land. Further the respondents were asked to state the interventions they engage to restore the water sources following floods. The results are in Figure 12.

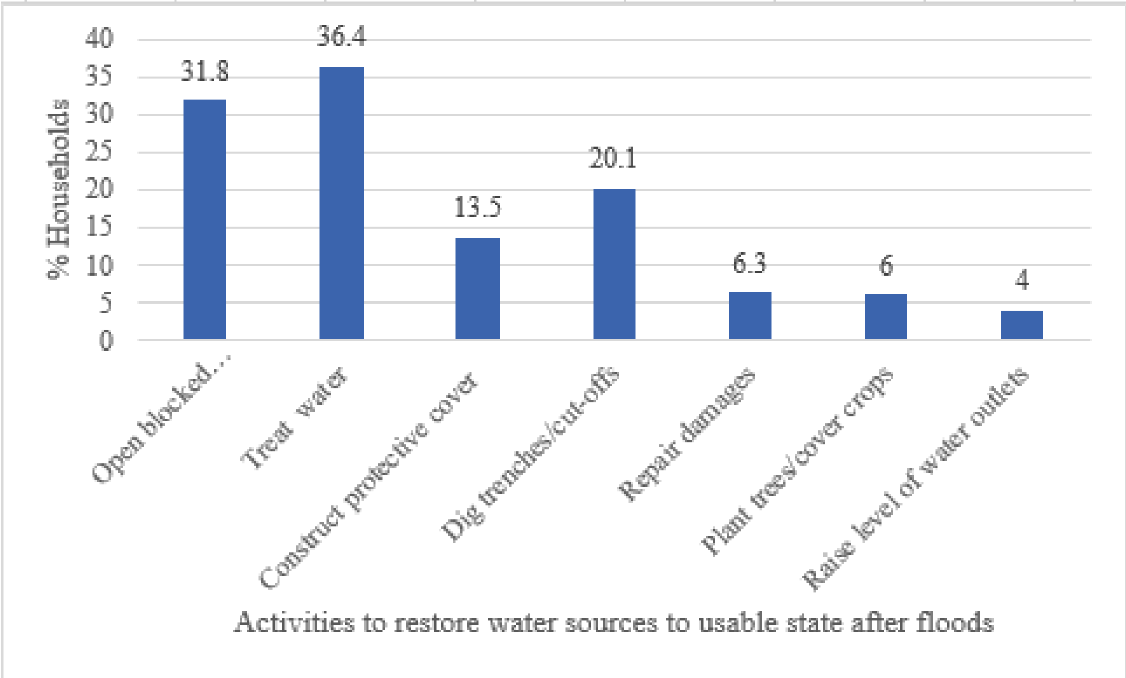

Figure 12: Activities Done to Restore Water Sources to Usable State After Floods

From the results in Figure 12, households engage in a total of seven (7) activities at different frequencies. The activities ranged in descending order of frequencies as follows: Most people (36.4%) treated their water, followed by opening sources blocked by silt (31.8%). The least practiced were raising the level of water outlets (4.0%) and digging trenches (2.0%) In order to determine recovery, the respondents were asked to state how successful the interventions in Figure 12 are in dealing with the effects of floods on soils (Table 9). Recovery was described by the success of interventions taken to restore water sources as a result of floods rated on a scale of 1-5 denoting: Never successful, Rarely Successful, Occasionally Successful, Often Successful and always Successful respectively. The mean of the success of each variable was calculated and the composite mean for all the variables derived to yield the Water Sources flood recovery index (Table 25). $M \geq 3$ was considered high whereas those below three ($M<3$) were considered low.

Table 25: Recovery From Impact of Floods on Water Sources Index

Recovery from	N	Mean	SD
Turbidity	301	3.07	1.44
Solid waste contamination (Rubbish/debris)	303	3.05	1.40
Contamination with fertilizer/pesticide residues from farming activities	288	2.46	1.51
Industrial effluents pollution	276	2.28	1.43
Surface water contamination	297	2.86	1.32
Ground water contamination	299	2.89	1.26
Algal blooms	293	2.43	1.40
Changes in taste of water	304	2.76	1.44
Sewerage contamination	293	2.10	1.22
Siltation	294	3.05	1.48
Recovery from Impacts of floods on water sources index	**306**	**2.60**	**1.00**

From the results in Table 25, the water sources flood recovery index (M=2.60) is below threshold pointing to weak recovery of water sources from impacts of floods. The interventions chosen are rarely successful. This may compromise the health of individuals predisposing them to water bone diseases (Nyakundi *et al.*, 2010).

Recovery From Impacts of Drought on Soils

Information was sought on whether the respondents undertake interventions to repair the land following the effects of drought. 90.23% of the respondents acknowledged doing something to restore the water sources while 9.7% reported doing nothing to repair damage on their land.

Further the respondents were asked to state the interventions they engage to repair the land (Figure 13).

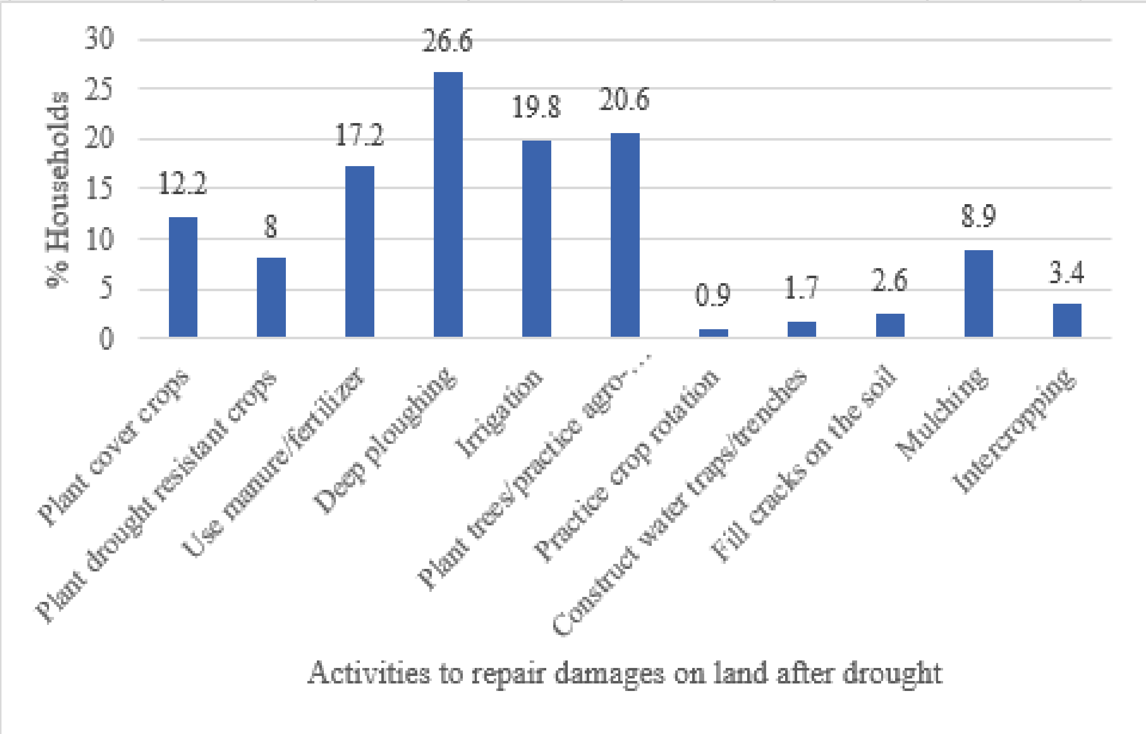

Figure 13: Activities to Repair Damages on Land Caused by Drought

From the results in Figure 13, for households to repair the land, a total of 11 interventions at varied frequencies are used. Most (26.6%) out of 349 respondents use deep ploughing, followed by 20.6%who practice agro-forestry, 19.8% who practice some form of irrigation and 17.2% who use manure/fertilizers. The rest of the interventions recorded below 50 users.

In order to determine recovery, the respondents were asked to state how successful the interventions in Figure 13 are in dealing with the impacts of drought on soils (Table 11). Recovery was described by the success of interventions taken to restore water sources as a result of floods rated on a scale of 1-5 denoting: Never successful, Rarely Successful, Occasionally Successful, Often Successful and always Successful respectively. The mean of the success of each variable was calculated and the composite mean for all the variables derived to yield the Soil drought recovery index (Table 26). Means of M≥3 was considered high whereas those below three (M<3) were considered low.

Table 26: Recovery From Impacts of Drought on Soils Index

Recovery	**N**	**Mean**	**SD**
Soil erosion (by wind)	313	2.87	1.39
Reduced soil productivity	313	2.83	1.35
Cracked soils	312	2.82	1.51
Crop failure	312	2.80	1.43
Lots of dust generated by loose soils (bowl dust)	309	2.78	1.48
Emergence of invasive species	310	2.55	1.51
Compacting of the soil	308	3.09	1.49
Loss of vegetation cover	313	2.69	1.44
Loss of soil moisture	312	2.59	1.49
Recovery from Impacts of drought on soils index	**313**	**2.76**	**1.23**

From the results in Table 26, the soil drought recovery index (M=2.76) is lower than average (M=3) implying that the interventions chosen are rarely successful. According to Al-Kaisi *et al.*, (2013), proper tillage management can reduce damages on soil structure. Tilling dry soils damages soil structure such that when substantial rain occurs, tilled soils will have fewer stable aggregates, resulting in significantly more soil erosion and loss of residual nutrients. Tillage thus decreases subsoil moisture recharge necessary for high yields during normal precipitation cycles. No-tillage or minimum tillage practices can decrease the effects of extreme weather conditions such as drought. This is not practiced in the study area where soon after the drought and in preparation for the planting seasons, the communities till their ground using deep ploughing and breaking the hard pans created by drought. Mulching is practiced as a coping mechanism (Table 18) though the mean scores are low (2.31).

Al-Kaisi *et al.,* (2013) also recommend crop residue management. Crop residue cover plays a significant role in soil sustainability. Foremost, surface residue physically protects soil from potential erosion during heavy rain events. Residue increases opportunities for recharging soil profile, providing greater water availability later in the growing season. To achieve these benefits from surface residue, management starts during harvest by leaving at least 30 cm (12 in) of corn stubble standing above the surface. Upright residue traps store moisture effectively and slow down slope water movement. It will be noted that the crop residues especially maize stalks are normally collected and used as a source of fuel or cut into silage for animal feeds. That means that crop residue management is poor hence recovery of soils would be minimal. Crop residue retention with no tillage improves water infiltration rate and conserves soil water content by reducing crusting and preserving soil structure. Lastly they recommend Cover Crops Management arguing that cover crops can play an important role by protecting soil from water erosion, improving soil structure, increasing organic matter, and significantly reducing nutrient losses. From the results of this study, households apply cover-cropping techniques to a large extent (M=3.16) as in Table 18 but the success of recovery of soils is still poor. This should be investigated further. Conservation agriculture is therefore the way to go. This will not only ensure bumper harvests but will also help in soil conservation for sustainable agriculture.

Restoring the Water Sources to the Original/Usable Status After Drought

Information was sought on whether the respondents undertake interventions to restore water sources following the effects of drought. 85.1% of the respondents acknowledged doing something to restore the water sources while 14.9% reported doing nothing to repair damage on their land. Further the respondents were asked to state the interventions they engage to restore water sources following drought (Figure 14).

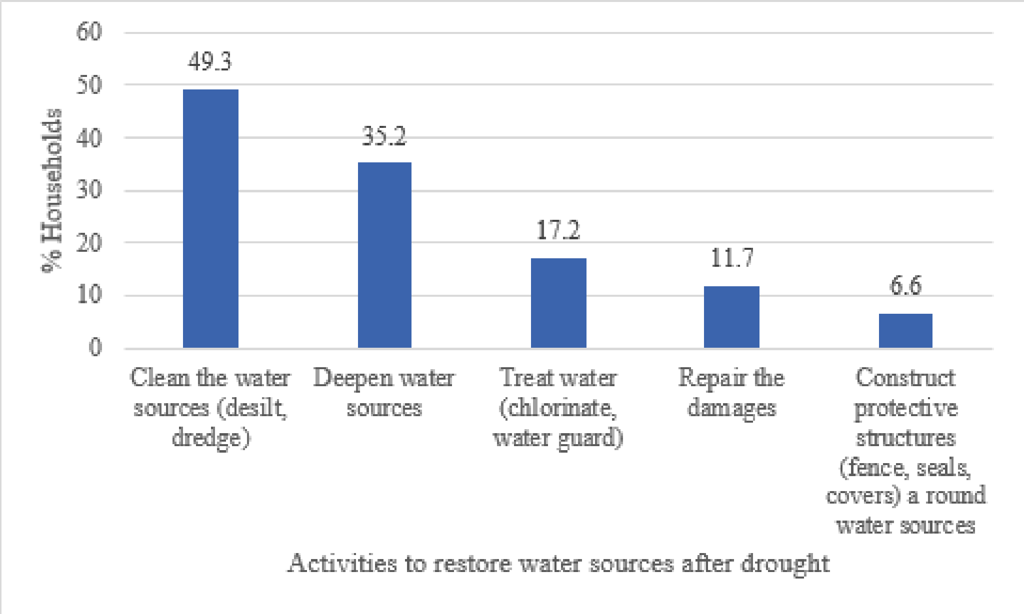

Figure 14: Activities to Restore Water Sources to Usable State After Drought

Whereas 49.3% clean the water sources, 35.2% deepen the water sources, 17.2% treat their water, 11.7% repair the damages on the water sources and 6.6% construct protective structures after the impacts of drought. In order to determine recovery, the respondents were asked to state how successful the interventions in Figure 14 are in dealing with the impacts of drought on water sources (Table 27). Recovery was described by the success of interventions taken to restore water sources as a result of floods rated on a scale of 1-5 denoting: Never successful, Rarely Successful, Occasionally Successful, Often Successful and always Successful respectively. The mean of the success of each variable was calculated and the composite mean for all the variables derived to yield the water sources drought recovery index (Table 4.22). $M \geq 3$ was considered high whereas those below three ($M<3$) were considered low.

Table 27: Restoring the Water Sources to the Original/Usable Status After Drought

Recovery from	**N**	**Mean**	SD

Pollution (dust, dry objects etc.)	308	3.06	1.52
Turbidity	308	3.01	1.37
Decreased water volumes the sources (rivers, lakes, water pans, dams)	306	2.51	1.40
Drying water pans	299	2.53	1.35
Drying river valleys	301	2.46	1.39
Drying wells	298	2.76	1.36
Lowered water table	306	2.52	1.29
Loss of riparian vegetation	309	2.40	1.35
Restoring water sources to original status after drought index	**309**	**2.62**	**1.13**

From the results (Table 27), the recovery index is slightly below average meaning that households are occasionally successful in the recovery process. The households are better able to deal with pollution (dust, and dry objects) (M=3.06) and turbidity (M=3.01) compared with other effects of drought on water sources. Overall the recovery index M=2.62 is relatively low compared to the Impact of drought on water sources Index which recorded a value of M=3.47 (Table 12). The discussion on this is based on the activities used to restore water sources following drought (Figure 14) and their effectiveness when applied. It is clear that the activities undertaken do not address how water volumes can be increased in the reservoirs and how the riparian vegetation can be restored. At the household level, most of the interventions applied are those for post-disaster remedial and even these are limited to the physical sources of water and not to the processes and activities that would influence the availability of water. Probably this is the responsibility of upstream water users who should be encouraged on sustainable land use to assure downstream users of quality and quantity of water. Similar approaches have been applied in the Lake Naivasha basin where upstream users have been engaged in a payment for environmental services program (Malel, 2020). In this scheme, the well to downstream users who are mainly horticultural farmers, have formed a group where they contribute money to be used to purchase farm inputs for selected upstream farmers who have been enlisted as implementers for sustainable agriculture practices on the their farms. The rationale behind this is that the upstream farmers would minimize impacts of poor farming methods that would cumulatively create negative impacts for downstream users in terms of availability of quality and quantity water. Management of water sources after drought should therefore be a continuous process and which involves multiple stakeholders whose activities influence the state of the water.

Recovery Index

In order to get the overall index of recovery from impacts of CCRD on the Environment, the mean of the four indices generated earlier was derived (Table 28). The threshold for recovery required to confer resilience to households is M=3.

Table 28: Recovery From Impact of CCRDs on Environment Index

Aspect	n	Mean	SD
Recovery from impacts of floods on soils	315	1.84	0.89
Recovery from impacts of floods on water sources	306	2.60	1.00
Recovery from impacts of drought on soils	313	2.76	1.23
Restoring water sources to original status after drought	309	2.62	1.13
Recovery from impacts of CCRDs on environment index	**343**	**2.22**	**0.95**

The results (Table 28) show that the overall recovery index from impact of CCRDs is M=2.22. On a scale of 1-5, the recovery index is below average implying poor resilience. Béné *et al.,* *(*2016), reported a strong correlation between poor recovery scores and poor households' resilience at the community level and concluded that full recovery might never be possible given the cyclical nature of shocks where even before recovery from the previous shock, another type of shock sets in, typical of the CCRDs affecting the environment in this study. Recovery could denote bouncing back to a functional state of the resource (Platt *et al.,* 2016) in this case soil and water sources. A recovery mean of (M=2.22) against an Impact Index of (M=3.47 derived in Objective 1) implies that the interventions in place to address effects of CCRDs by households are weak.

The difference in recovery among the households from the three divisions, which participated in the study, was determined using the ANOVA. The descriptive statistics of the procedure are presented in Table 29

Table 29: Means and Standard Deviations of Recovery From Impact of CCRDs on the Environment by Division

Division	n	Means	SD
Kadibo	109	2.17	1.08
Nyando	194	2.24	0.91
Lower Nyakach	40	2.29	0.81

Table 29 shows that the means (M = 2.29, SD = 0.81) of Lower Nyakach was the highest followed by those of Nyando (M = 2.24, SD = 0.91) and Lower Nyakach (M = 2.17, SD = 1.08) respectively. An examination of these results indicates that they were comparable. The results suggest that the differences among the means were statistically significant. To determine this, a further interrogation of the results was done using ANOVA. The results of this test are in Table 30.

Table 30: Comparison of Recovery From Impact of CCRDs on the Environment by Division

Scale	Sum of Squares	df	Mean Square	F-ratio	p-value
Between Groups	0.483	2	.242	.265	.768
Within Groups	310.501	340	.913		
Total	310.985	342			

The ANOVA test results reveal that difference in recovery from the impact of CCRDs on the environment among Household heads by division was not statistically significant at the .05 level, $F(2, 340) = .265$, $p = .768$. Multiple comparison test was not conducted as the divisions were similar with regard to recovery from impact of CCRDs on the environment.

4.5.3 Resilience Index

Resilience was measured with regard to households' ability to cope with and recover from the impacts of CCRDs. The overall resilience index was thus the mean of the indices of the two components (Table 31) from the three divisions involved in the study. The threshold for resilience is M=3.

Table 31: Resilience Index: Means and Standard Deviations of Coping and Recovery

Scale	n	Mean	SD
Coping with Impact of CCRDs	342	2.84	0.90
Recovery from Impact of CCRDs	343	2.22	0.95
Resilience index	340	2.54	0.79

The resilience index of 2.54 is below the threshold. This is indicative of a community that is struggling to remain resilient. The resilience index (Table 31) is below the threshold and is therefore suggestive of poor resilience. When the coping and recovery capacities are low, a community suffers from losses and damage and its condition worsens (Joerin *et al.*, 2012). The study recorded significant impact of CCRDs on the environment in objective one, signifying damages and losses and therefore it would be expected to impact on resilience. Resilience is also dependent on a coping strategy (Daniel, 2011) and therefore, if the coping strategy is weak (Table 20), the latter would lack the strength to confer resilience. In this study both the coping and recovery are low implying inadequate capacity to deal with the impacts of floods and drought on the environment. The lower recovery index compared to the coping index points to a picture where the coping mechanisms are not elaborate or efficient enough to enable commensurate recovery. Recovery could also be compromised by the frequent disasters, which hardly leave room for households to recover before another disaster strikes (Parsons *et al.*, 2016). Simple linear regression test was used to establish whether Impact of CCRDs on the environment influences resilience (Table 32).

Table 32: Regression of Impact Against Resilience

Scale	B	Std. Error	Beta	t-value	p-value
(Constant)	1.063	.243		4.377	.000
Impact of CCRDs on the environment	.426	.069	.318	6.163	.000
r = .318, R^2 = .101, F(1,338) =21.309, p = .000					

Table 32 shows that, Impact of CCRDs on the environment is positively related to resilience. It explains 10.1% (R^2 = .101) variation in the outcome. The influence of the explanatory variable on resilience is statistically significant F (1,338) =21.309, p = .000. The Mathematical model for predicting resilience is as follows:

Resilience = 1.063 + .426 Impact of CCRDs on the environment.

From the regression analysis (Table 32), Impact significantly influences resilience. Despite frequent experiences with CCRDs, the households coping and recovery is still low implying that past experience with CCRDs have not improved the capacity to handle the disasters pointing to poor adaptation (Joerin *et al.*, 2014). In such circumstances these households are likely again to be hit in future by strong CCRDs. Béné *et al.*, (2016), assert that the ultimate impact of a resilience intervention lies in the types of adequate responses put in place by the households in the face of adverse events. Resilience when applied to human systems is best conceptualized as a capacity and process rather than as an outcome (Imperiale and Vanclay, 2016), and as such it can be said that the households in the study area are not yet resilient to impact of CCRDs on the environment but they are on the path to becoming resilient.

In order to determine if there is a significant difference among households from the three divisions that participated in the study, an ANOVA test was carried out. The descriptive statistics of the procedure are presented in Table 33.

Table 33: Means and Standard Deviations of Resilience by Division

Division	**n**	**Means**	**SD**
Kadibo	109	2.60	0.09
Nyando	191	2.51	0.05
Lower Nyakach	40	2.49	0.09

Table 33 shows that the mean (M = 2.60, SD = .09) of Kadibo was the highest followed by those (M = 2. 51, SD = 0.05) of Nyando Lower Nyakach (M = 2.49, SD = 0.09) respectively. An examination of these results indicates that they were comparable. The results suggest that the differences among the means were not statistically significant. The decision to accept or reject the hypothesis which states that there is no significant differences in resilience among the three divisions could not be made on the basis of these results only. This decision was made based on the results of the ANOVA test. The results of this test are in Table 34

Table 34: Comparison of Resilience Among Household Heads by Divisions Using the ANOVA Test

Scale	Sum of Squares	df	Mean Square	F-ratio	p-value
Between Groups	.625	2	.312	.500	.607
Within Groups	210.327	337	.624		
Total	210.951	339			

The ANOVA results indicate that the differences in resilience among Household heads from Kadibo, Nyando and Lower Nyakach was not statistically significant, F (2,337) = .500, p = .607. This means that the resilience of households of the three divisions were similar. These results support the hypothesis, which states that there is no significant difference in resilience among the three divisions. This hypothesis was accepted on the basis of these results.

4.6 Objective 3. Influence of Impact of CCRDs on Coping of Households

This objective sought to determine the influence of Impact of CCRDs on the environment on the coping mechanisms of households in lower Nyando river basin, Kisumu County. In order to determine this, the Coping index generated in objective two was regressed against the Impact index generated in objective one (Table 13) to determine the influence. Simple linear regression was performed to determine the influence of Impact of CCRDs on the environment on the coping capacity of households (Table 35).

Table 35: Coping With Impact of CCRDs on the Environment Index

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta		
(Constant)	1.316	.281		4.683	.000
Impact of CCRDs on the environment	.439	.080	.286	5.498	.000
r = .286, R^2 = .082, F(1,340) =30.225, p = .000					

The results in Table 35 yielded a positive (r = .286) relationship between impact of CCRDs on the environment and the households coping capacities. The explanatory variable accounts for 8.2% (R^2 = .082) variation in coping with impact of CCRDs on the environment. The effect of impact of CCRDs on the environment of the outcome is statistically significant at the .05 level, F(1,340) =30.225, p = .000 hence rejecting the null hypothesis Ho_2 which says that there is no significant influence of Impact of CCRDs on the environment on the has no the households' coping mechanisms in lower Nyando river basin, Kisumu County and affirming that Impact of CCRDs on the environment, significantly influences the coping capacity of households in lower Nyando river basin, Kisumu County. This relationship yielded a linear equation as follows:

Coping with impact of CCRDs on the environment = 1.316 + .439 Impact of CCRDs on the environment.

The positive (r=.286) implies that there is a positive relationship between the two variables in that as the impact increases, so do the households coping capacity increase. The variation of 8.2% can be accounted for by the fact that human beings are naturally resilient and when faced with a situation, they migrate or adapt. In most cases, adaptation is the more immediate option and the steps to adaptation constitute coping. The coping index M=2.84 (Table 20) is lower than the Impact index M = 3.48 (Table 13) implying that the cumulative effects of CCRDs on the environment outweigh the coping capacity of households. Efforts therefore need to be enhanced to reduce the impacts of floods and drought on the environment in order to minimize the impacts.

The Key informants noted that even when households engage various interventions, the level and intensity of the interventions is still low due to lack of resources and knowledge of the importance of some quick win interventions such as mulching. The low uptake of interventions is also attributed to poor economic power of the households. This areas has recorded high poverty levels and this is compounded by a largely subsistence economy which is heavily reliant on the varying climatic conditions. They also decried the minimal education that has been conducted on proper land management specifically land repair practices has been conducted necessitating the need for enhanced extension services.

4.7 Objective 4: Influence of Impact of CCRDs on Recovery of Households

Objective four (4) sought to establish the influence of impact of CCRDs on the environment on the recovery of households in lower Nyando River Basin of Kisumu County. In order to determine this, the impact index generated in objective one (Table 13) was regressed against recovery index (Table 28). A simple linear regression was performed as in Table 36.

Table 36: Regression of Impact Index Against Recovery Index

Model	Unstandardized Coefficients	Standardized Coefficients	t-value	p-value

	B	Std. Error	Beta		
(Constant)	.825	.292		2.823	.005
Impact of CCRDs on the	.404	.083	.255	4.86	.000
r = .255, R^2 = .065, F(1,341) =23.621, p = .000					

From the results in Table 36, the relationship between impact of CCRDs on the environment and the households 'recovery is positive (r = .255). The explanatory variable explains 6.5% (R^2 = .065) variation in households' recovery from impact of CCRDs on the environment. The effect of Impact of CCRDs on recovery was statistically significant at the .05 level, F (1,341) =23.621, p = .000, hence rejecting the null hypothesis Ho_4which states that impact of CCRDs on the environment has no significant effect on the recovery of households in lower Nyando river basin, Kisumu County and affirming that Impact of CCRDs on the environment, significantly influences the recovery of households. The results imply that Impact is correlated with recovery and that the severity or strength of Impact would influence recovery by 6.5%. Béné *et al.*, (2016) demonstrated a high significant (P< 0.0001***) correlation between recovery and household resilience.

Households therefore have no choice but to plough in more resources to recover when the Impact of CCRDs increases. In other circumstances, such resources would have been put to other uses. Platt *et al.*, (2016) noted that successful recovery is not just about speed but also relates to quality. Quality is, however, difficult to measure since it is subjective and dependent on individual appreciation. A recovery index of M=2.22 though on the lower side does not mean the households are completely unable to recover, but rather, the degree of recovery is low and this renders them vulnerable. Probably the high frequency of floods and drought shown in this study give the farmers no time to recover from previous impacts such that they are unable to accumulate assets or acquire the skills and knowledge necessary for adapting to future climate changes (Mutekwa, 2009). A combination of pre-existing resilience and actual response, to an extent, determines recovery outcomes. Platt *et al.*, (2016) conclude that focus should be placed on the factors that increase resilience and improve response. This being the case, efforts should target mitigating disaster risks at the various stages of disasters so that the severity of the impact is reduced (Khalili *et al.*, 2015). UNDP (2016) asserts that proper planning with a focus on risk and vulnerability reduction and learning from past experiences leads to successful recovery of natural environment following such disasters. The Resilience Cost Index (RCI) produced by Vugrin *et al*., (2011) recognizes that the recovery effort is as important as the Impact of a disaster on a system in resilience assessment. This (RCI) model factors in the magnitude of the recovery effort to quantify the resilience. According to this model, Systemic Impact plus Total Recovery Effort determines the resilience. The higher the total cost of recovery, the lower the resilience of a system but this would greatly depend on the impact of the disaster on the system. To bring this into perspective, CCRDs affects the environment in different ways and the extent varies in each case. Some impacts are more severely felt going by the rankings in the case of this study but all the impacts combined would give us the magnitude of the impacts referred to here as the Impact Index. A key informant (Nyando sub-county agricultural officer) reiterated that if this impact is huge (strong), the affected households plough in more resources in terms of time, money and physical labor to mitigate each individual effect to a level where the soils and water sources return to a functional state. More often than not, most households invest minimal resources to realize recovery since priority is given to immediate needs like food and money for school fees. When recovery is realized such that the natural assets are in the functional state, these environmental resources would be able to supply the goods and services due to the community such as nutrients for food crops, clean water for domestic use, and carbon sequestration amongst others. Impact therefore is a huge determinant of resilience and it works in concert with recovery effort.

4.8 Objective 5: Influence of Socioeconomic Factors on the Capacity of Households to Cope With Impact of CCRDs

Objective five (5) sought to examine the influence of socioeconomic factors on the capacity of households to cope with Impact of CCRDs. The socioeconomic factors considered in addressing this objective were gender (sex), age, level of education and the farm size owned by the respondents. These factors have already been covered and discussed under the demographics (section 4.31)**.** In order to determine the influence of socioeconomic factors on coping capacity of households to impacts of CCRDs, multiple regression analysis was done. Gender, age and level of education were converted into dummy variables given that gender was measured at nominal scale while age and level of education were at ordinal scale (Table 37).

Table 37: Multiple Regression: Socioeconomic Factors and Coping of Household Heads

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta		
(Constant)	2.962	.134		22.088	.000
Gender dummy	.239	.104	.131	2.299	.022
35 years and below dummy	-.182	.172	-.063	-1.058	.291
36 - 45 years dummy	-.135	.130	-.066	-1.033	.302
56 - 65 years dummy	-.587	.150	-.242	-3.910	.000
66 years and above dummy	-.390	.158	-.165	-2.473	.014
Did not go to school dummy	-.175	.273	-.037	-.640	.523
Level of education (Lower primary)	-.211	.183	-.065	-1.149	.251
Level of education (Secondary school)	.144	.116	.073	1.245	.214
Level of education (Tertiary)	.067	.169	.023	.398	.691
Farm size	-.007	.033	-.012	-.216	.829
r = .286, R^2 = .082, F(10, 327) =2.922, p = .002					

Table 37 shows a positive relationship (r = .286) between the socioeconomic factors and capacity of households to cope with impact of CCRDs. All the factors had no significant influence on the outcome except gender (t = -2.299, p = .022), 56 – 65 years (t = -3.910, p = .000) and 66 years (t = -2.473, p = .014) and above age groups. The socioeconomic factors accounted for 8.2% (R^2 = .082) variation in capacity of households to cope with impacts of CCRDs. The explanatory variables had a statistically significant effect on capacity of households to cope with impact of CCRDs. F (10, 327) =2.922, p = .022. These findings resonate with those of Twymann *et al.*, (2014) that women in Nyando, are more likely to have learned and adopted coping capacities out of experience compared to men due to more engagement on farm agricultural activities hence higher coping capacity.

Béné *et al.*, (2016) cited experience as one of the subjective factors that influence responses to impacts of particular events at the individual, community and societal levels in communities. Their study confirmed that resilience (from the coping lens) is socially constructed and as such gender would play a big role. They also reported negative correlation between age and resilience and attributed their findings to the advantage conferred on the young people by virtue of having less social, familial and financial commitments than older households, a capacity which can be decisive in the context of adaptation/transformation to change. In this study the negative coefficients imply that the older the farmers the less their capacity to cope hence the negative coefficients. This is practical given that the more elderly people may lack the energy and agility to try out many coping strategies unlike the younger people. These findings contradicted those of Mardy *et al.,* (2018) who found a positive correlation between age and drought coping strategies imputing that as farmer's age, they were more likely to practice drought coping strategies. They opined that the older farmers possess a higher level of knowledge regarding Climate Change and drought through their own dealings and experience.

Farm size had no significant influence on coping capacity. These results contrast with other studies such as those of Mardy *et al.,* (2018) who found out that farm size amongst other variables was significantly associated with the choice of coping strategy that the farmers employed. They argued that some crop-based coping strategies require a larger farm size hence farm size influenced farmers' choice of which drought coping strategies to use. Oluoko-Odingo (2004) on the other hand, found a negative correlation between farm sizes and food crop production and attributed this to land fragmentation. The rational was that, small farm sizes are uneconomical since so much effort is put in it in terms of labor and inputs and yet the harvests are minimal. This study, just like that of Béné *et al.*, (2016) found no significant relationship between the education level of the household head and household resilience. Education level did not have a significant effect on coping capacity. This could be attributed to the fact that education does not necessarily translate into assets that can be mobilized to cope with floods or drought. In any case, the majority of household heads interviewed had primary level of education.

Key informants admitted that very little education on management of effects of floods and drought on soils and water sources had been done to the community. This is exacerbated by the fact that, the line Ministries of Agriculture, water, irrigation and health at the location level are grossly underfunded since the promulgation of the new constitution in 2013, which saw devolution of services to county level take root. Since then, extension services have been totally crippled. Adult education and learning is therefore not provided for in the study area and dissemination and uptake of new techniques and technology that would mitigate the CCRDs are wanting. Okayo *et al*., (2015) also established that educational level did not influence high uptake of precautionary measures against floods in Nyando Sub-county. They attributed this to complacency of the community to flooding and its effects as long as they got relief food distributed to them. Extension services need to be revived and soil and water management should be given prominence.

The results therefore reject the null hypothesis $Ho_{5,}$ which states that there is no significant influence of Socio-economic factors on households 'ability to cope with impacts of CCRDs on the environment in lower Nyando river basin, Kisumu county and confirm that socio-economic factors influence coping with impacts of CCRDs on the environment by households.

4.9 Objective 6: Influence of Socioeconomic Factors on households Recovery From Impact of CCRDs

This objective sought to determine the Influence of socioeconomic factors on households' recovery from Impact of CCRDs. In order to determine this, socioeconomic factors namely gender, age, level of education and farm size captured in section 4.31 were regressed against the recovery index (Table 28) determined earlier using multiple regression analysis. The results are displayed in table 38

Table 38: Multiple Regressions – Socioeconomic Factors and Recovery From Impacts of CCRDs

Model	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta		
(Constant)	2.206	.144		15.338	.000
Gender	.130	.111	.067	1.17	.243
35 years and below dummy	.225	.184	.074	1.227	.221
36 - 45 years dummy	.267	.139	.123	1.916	.056
56 - 65 years dummy	-.112	.161	-.043	-.695	.488
65 years and above dummy	.251	.167	.102	1.501	.134
Did not attend school dummy	-.315	.280	-.066	-1.127	.261
Level of education (Lower primary)	-.311	.194	-.091	-1.605	.109
Level of education (Secondary school)	.220	.124	.105	1.778	.076
Level of education (Tertiary)	-.066	.181	-.022	-.366	.714
Farm size	-.075	.034	-.124	-2.217	.027
r = .246, R^2 = .060, F(10, 328) =2.108, p = .023					

The relationship (r = .246) between the socioeconomic factors and households' recovery from impacts of CCRDs was positive. All the factors had no significant influence on the outcome except farm size (t = -2.217, p = .027). The social factors accounted for 6.0% (R^2 = .060) variation in households' recovery from impacts of CCRDs. The explanatory variables had a statistically significant effect on households recovery from impacts of CCRDs. F (10, 328) =2.108, p = .023. These results are consistent with other studies in the area where Oluoko-Odingo (2006), found a negative correlation between farm sizes and food crop production and attributed this to land fragmentation. The rationale is that small farm sizes are uneconomical. Kassem, Bello, Alotaibi, Aldosri and Straquadine (2019) identified farm size as one of the factors that significantly influenced adoption of adaptation measures to climate change and went on to explain that farmers with larger farms had a higher probability of adopting adaptation measures. The rationale is that an increase in the area cultivated minimized the risk, allowing farmers to gain a higher yield. This current study however yielded a negative coefficient of land (-0.75, Table 38) implying that those with big sizes of land do not put in a lot of effort to recover, yet as LVBC (2011) reported, the smaller the farm, the more vulnerable the owners are to drought and flooding. This finding calls for further interrogation, as the opposite would be expected.

The size of land can be interpreted to being directly proportional to assets. The bigger the land size, the bigger the assets, and this can be used to bring about a positive change or impact (in this case, recovery), a classic case of economies of scale. The same cannot be argued of the other variables. Gender (sex), age and level of education in this study did not have significant influence on the recovery.

Recovery as defined and operationalized is pegged on the coping interventions. It is therefore logical to argue that once the intervention is in place, these last three variables would play very little role in the success of the interventions. Similar findings were recorded by Béné *et al., (*2016), who found out that education and sex of the household head did not appear to influence the level of household resilience. Their study measured resilience through the lens of recovery, as was this study too. On the other hand, age despite recording a significant influence on coping did not record similar influence in recovery. In contrast to this study, Meyer (2013) cited in Ranjan and Abenayake, (2014) found out that age of respondent showed negative correlation with the time taken for recovery. However when they removed the entries of the respondents below age 30, the correlations between age and time taken for recovery revealed a strong correlation of r=7. Whereas, their study focused on time taken to recover, the current study focused on the levels of success without specifying the time it took the households to recover.

Given the small though significant influence that social factors (farm size) had on recovery in this study, it is imperative that other factors outside the scope of this study influences recovery. Time, income and previous experience with disasters of the households could be the other contributory factors. A study into other factors like awareness of appropriate interventions, economic factors and extension services should be conducted to determine how they too could influence resilience. The results reject the null hypothesis Ho_6, which states that socio-economic factors do not significantly influence recovery of households from the impacts of CCRDs on the environment in lower Nyando river basin, and confirm that social factors influence recovery of households from impacts of CCRDs on the environment.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter deals with the summary of the results of the six (6) objectives and (5) hypotheses tested in this study. It also includes the conclusions, recommendations and suggestions for further study.

5.2 Summary of research findings

Objective 1: To determine the Impact of CCRDs on the Environment of households in lower Nyando River Basin. The research established that households in the three divisions experience climate shocks in the form of floods and drought. Overall, the Impact is above average implying that floods and drought impact on soils and water sources to a large extent. Furthermore, the Impact of CCRDs on environment was not significantly different across the divisions namely Kadibo, Nyando and Lower Nyakach, which participated in the study. The results accepted the null hypothesis H_{01} which states that there is no statistical significant difference in Impact of CCRDs on the environment of households in lower Nyando river basin Kisumu County

Objective 2: To determine the resilience of households in lower Nyando river basin, Kisumu County to the impact of CCRDs on the environment. Overall, the coping capacity was lower compared to the Impact alluding to inadequate coping capacity and a community that is struggling to remain resilient. On the other hand, the interventions households engage recorded low levels of success in restoring the soils and water sources to a usable state. Cumulatively the recovery index was much lower than the Impact index and coping index. From the results, recovery can be interpreted as rarely successful. Overall, the resilience index is below the threshold. In addition Impact of CCRDs significantly influences resilience and the relationship is positive. Resilience was not statistically different among the three divisions namely Kadibo, Nyando and Lower Nyakach that participated in the study. The results therefore accepted the null hypothesis H_{02} that states that there is no statistical significant difference in resilience of households to impact of CCRDs on the environment in lower Nyando River Basin Kisumu County.

Objective 3: To determine the influence of Impact of CCRDs on the environment on the coping mechanisms of households in lower Nyando river basin, Kisumu County. Impact was found to significantly influence coping by households. The results also showed disparity in the ability to apply interventions across the wards. The results rejected the null hypothesis H_{03} which states that Impact of CCRDs on the environment has no statistical significance on coping of households in in lower Nyando river basin Kisumu County and confirmed that Impact of CCRDs on the environment of Households significantly influences their coping mechanisms.

Objective 4: To establish how the Impact of CCRDs on the environment influences recovery of households in lower Nyando river basin, Kisumu County. The relationship between Impact and recovery of households was determined in order to make a conclusion on the influence of impact on recovery. Impact was found to significantly influence recovery hence rejecting the null hypothesis H_{04} which states that Impact of CCRDs on the environment has no statistical significance on the recovery of households' in lower Nyando river basin Kisumu County and confirmed that Impact of CCRDs on the environment significantly influences the recovery of households. Households therefore have to plough in more resources to recover when the Impact of CCRDs increases. Such resources would have been put to other uses. The low recovery index points to inadequate coping mechanisms, an issue that needs quick redress. Take to conclusion

Objective 5: To examine the influence of socioeconomic factors on the households' ability to cope with impacts of CCRDs on the environment in lower Nyando river basin, Kisumu County. Gender and Age had a significant influence on households' coping capacity with impacts of CCRDs. Women are better at engaging coping mechanisms than men. On the other hand, farm size and level of education had no significant influence on coping capacity. The results rejected the null hypothesis Ho5 which states that there is no statistical significant influence of socioeconomic factors on households' ability to cope with effects of CCRDS on the environment in lower Nyando River Basin, Kisumu County.

Objective 6: To investigate the influence of socioeconomic factors on households' ability to recover from the impacts of CCRDs on the environment in lower Nyando River Basin Kisumu County. Farm size had a significant influence on the recovery of households from Impacts of CCRDs. The results rejected the null hypothesis H_{06} which states that socioeconomic factors do not significantly influence recovery of households from the effects of CCRDs on the environment in lower Nyando River Basin Kisumu County.

5.3 Conclusions:

The effects of floods and drought that are experienced in the Lower Nyando River Basin in cyclical manner, affects the soils and water sources in the area in a great way. The range of effects spans physical, biological and chemical impacts, which manifests in declining environmental quality. The level of impact seems to be uniformly widespread across Kadibo, Nyando and Lower divisions, which participated in the study. Cumulatively the impact is high and is exacerbated by the increasing frequency of floods and drought.

The resilience of households in lower Nyando River Basin was found to be low. This was due to poor coping and recovery reported in the divisions under study. Despite the high impact CCRDs on the environment, the level at which households engage active interventions to mitigate the impact is relatively low. This is probably due to the low poverty index reported in addition to being heavily dependent on rain fed and soil agriculture. Due to the increased frequency of floods and drought, the households are hard pressed to engage coping mechanisms whose effect weakens over time given since there is little time available to cope before the next disaster strikes. As a result of this, the recovery is rarely successful and this translates into low resilience of the households. If this trend continues, the natural capital might lose its capacity to support sustainable livelihoods and healthy ecosystems.

Impact was found to influence both coping and subsequent recovery from impacts of CCRDs on the environment. Households were found to engage many coping mechanisms ranging from simple day to day activities like treating drinking water, draining waterlogged soils, to more complex and long term initiatives like construction of check dams, agroforestry, protecting water sources, and building gabions. The study also showed that households are keen on fixing the problems meted on their soils and water sources by CCRDs. They do this through multiple interventions to curb impacts arising from floods and drought. Construction of protective structures, planting trees and cover crops were the most popular despite them being long-term remedies. Intercropping, mulching, and contour ploughing recorded lower percentages pointing to low uptake of Conservation Agriculture. Low scale adoption of the interventions, shortage of resources and/or lack of knowledge on the benefits of the interventions could be contributing to the poor resilience.

Despite households engaging various interventions, the recovery level is still low due to lack of resources and poor uptake of quick win interventions such as mulching. Minimal education on awareness of land repair practices has been conducted in the study area necessitating the need for enhanced extension services. The study also showed that interventions that stand to benefit individual households by virtue of ownership or proximity to the water source and where failure to take action would render them more vulnerable, were more popular as opposed interventions that would potentially benefit communal interests such as rehabilitating damaged river banks, restricted abstraction and grazing in wetlands. A possible explanation to this is that individual interest supersedes communal interests and therefore individuals do not perceive common property as their responsibility hence few people would be moved to protect an asset for the common good. Extension services are weak and so is law enforcement especially on riparian land.

Socio-economic factors namely Gender and Age, significantly affects the coping mechanisms of households of Lower Nyando River Basin but level of education and farm size do not significantly affect the recovery of households of Lower Nyando River Basin but gender, age, level of education and farm size do not. Women seem to cope better than men probably due to incremental learning as a result of constant engagement in on-farm agricultural activities as opposed to men who mostly engage in off-farm activities. In addition to this, the older farmers were less able to cope compared to the younger farmers. Those with bigger farms were no more motivated to engage coping mechanisms than those with smaller farms. Limited community extension education on the management of CCRDs on the environment was reported in the study area due to underfunding of the line ministries especially agriculture extension as revealed by Key informants.

The size of land can be interpreted to being directly proportional to assets. However those with bigger pieces of land do not put in much effort to recover. The bigger the land size, the bigger the assets and this can be used to bring about a positive change or impact (in this case, recovery), a classic case of economies of scale. However in the absence of adequate coping mechanisms, the large farms would not be able to recover significantly.

5.4 Recommendations

The study recommends the following as a way of reducing the Impact of CCRDs and enhancing the resilience of households:

i. The causes of CCRDs namely floods and drought should be addressed adequately to mitigate their impact on the households. A catchment approach to conservation should be embraced.

ii. Efforts should be made to enhance the resilience of households to impacts of CCRDs by reducing the Impact of CCRDs on the environment through engaging adequate and effective coping mechanisms.

iii. There is need to upscale the coping mechanisms currently employed by households in the aftermath of CCDRs through enhanced extension services by empowering and supporting the community in the study area to identify the appropriate coping mechanisms in order to deal with the inevitable impacts of CCRDs on their land and water sources. Conservation Agriculture should be encouraged for sustainable land use. The County government of Kisumu should also streamline resource flow to the relevant county departments to enhance extension services.

iv. There is need for diversification of livelihoods from subsistence farming to other income generating enterprises to cushion against Impacts of CCRDs. The enhanced economic power would facilitate investment in recovery efforts.

v. Socioeconomic factors especially gender, age and farm size should be considered when addressing resilience in the study areas.

vi. Initiate Payment for Environmental Services (PES) Scheme in the upper catchment where upstream users (catchment) are given incentives to engage conservation activities that would in turn benefit downstream users. This would also encourage a catchment approach to management of natural resources. Concerted efforts from all the stakeholders ranging from the resource users, extension officers, policy makers and educators need to be consolidated to tilt the equation to low Impact and high coping (typical resilient communities).

5.4.1 Recommendations for Further Research

The research has identified the following areas for further study in order to complement the current knowledge:

i. This study used a descriptive survey design, further studies incorporating longitudinal designs to enable data collection over a longer period of time should be undertaken to establish trends.

ii. Resilience has many dimensions apart from the two (coping and recovery) considered in this study. Further studies should be conducted addressing the other dimensions of resilience such as institutional, political and adaptive capacity.

iii. The study only considered four (4) Socio-economic factors, yet there are many other socio-economics factors. Future studies could explore the impact of the other socio-economic dimensions such as income, type of land use amongst others in resilience studies in this area.

5.4.2 Policy Recommendations

From the study, the following should be amplified in the policy documents.

i. There is need to strengthen the regulations applicable to water pollution to ensure polluters of water e.g. farmers who use fertilizers whose residues end up in water bodies and soils pay for the pollution or meet the cost of restoration by downstream uses. Payment for Environment Services (PES) Schemes should be mainstreamed in this part of the regulations to enhance EMCA 2012 which provides for management of water pollution (Section 72: 2a, 2b).

ii. Kenya Constitution (2010), devolved functions and services to the counties. It states that county governments shall decentralize its functions and the provision of its service to the extent that it is efficient and practicable to do so. Seemingly the resources have not been devolved effectively to the locations and divisions. Article 60 states that Land to be used and managed in a manner that is equitable, efficient, productive and sustainable, and in accordance with the following principles: c) sustainable and productive management of land resources e) sound conservation and protection of ecologically sensitive areas. The government should put in place a comprehensive framework and strengthen the implementation of the principles enshrined in this article. There is need for continuous implementation of agricultural extension policies and environmental awareness campaigns and infusion of technology in agriculture at the sub county level. Mandatory capacity building (in-service training) for the agricultural officers to disseminate new information and technology should be mainstreamed into annual budgets.

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APPENDICES

Appendix1: Household Heads Questionnaire

Serial Number …………

Dear Respondent,

I am a PhD candidate at Kabarak University currently conducting a field research as part of the coursework. The research is titled "A*ssessment of community resilience to impacts of climate change related disasters on the environment in Nyando Sub-County, Kenya*. I believe that as a resident of the sub county, you have information that can significantly contribute towards the success of this study. I am therefore kindly requesting you to be part of the study by filling this questionnaire. May I assure you that any information given will be treated with utmost confidentiality and will be used for the purposes of this research only.

Instructions

i. Do not write your name on the questionnaire

ii. Indicate the responses by placing a tick in the selected option or by providing answers to the questions in the given spaces

<u>Section A: Bio-data</u>

1. Age in years ……………….
2. Gender Male [ ] Female [ ]
3. Highest level of education Primary [ ] Secondary [ ] Tertiary institutions [ ] University [ ] others (specify) ……………………..
4. Division ……………………………….
5. Location …………………………………
6. Estimated distance (in kilometers) from river channel ………………………….

Section B: Impact of floods on Soil

1. Size of your farm (land) you live on in acres………………………………
2. Land tenure Rented [ ] Lease [ ] Owned [ ] others (specify) …..

3. List the farming and economic activities carried out on the land:

   a.……………………………………………………………………………………

   b.……………………………………………………………………………………

   c.……………………………………………………………………………………

4. Do you experience floods? Yes [ ] No [ ]
5. If the answer to item "4" is "Yes", how frequently do you experience floods in a given year? Never [ ] Rarely [ ] Occasionally, Often [ ] Very often [ ]
6. The items in the Table below are on effects of floods on soil. Using the given scale, indicate the extent to which floods impact on soil on your land

Scale: No Extent **(NE),** Little Extent (**LE),** Moderate Extent (**ME**), Large Entent (**LE**) Very Large Entent (**VLE**)

Effect	**VLE**	**LE**	**ME**	**LE**	**NE**
Washing away top soil					
Solid waste contamination (mud and debris)					
Contamination with fertilizer and pesticide residues					
Creating gullies					
Leaching nutrients in the soil					
Eroding vegetation cover					
Introduction of invasive species (e.g. striga)					
Waterlogging					
Soil and sediment contamination					
Reducing fertility /poor soils (not a direct impact)					
Other (specify)					

Section C: Impact of floods on Water Sources

1. Indicate the sources of water for domestic use in your homestead
   a. Well [ ]
   b. Spring [ ]
   c. Pond [ ]
   d. River/Stream [ ]
   e. Lake [ ]
   f. Piped water [ ]
   g. Others (Specify) ………………………….
2. Where are the water sources located My farm [ ] National/County Government land [ ] Community land [ ] Neighbor's farm [ ]
3. What are the main uses of water in the homestead
   a. Cooking [ ]
   b. Washing [ ]
   c. Watering livestock [ ]
   d. Bathing [ ]
   e. Irrigation [ ]
   f. Others (Specify) ………………………………………………………………
4. What are the major pollutants of your water sources (e.g. human waste, agricultural activities residues, livestock, waste from industries, flood or drought related)
   a. ……………………………………………………………………………….
   b. ……………………………………………………………………………….
   c. ………………………………………………………………………………...
   d. ………………………………………………………………………………...
5. Indicate the extent to which floods affect your water sources in areas described in the table

below: Use the given scale

Scale: No Extent (NE), Little Extent (LIE), Moderate Extent (ME), Large Extent (LE), Very Large Extent (VLE)

Variables	**VLE**	**LE**	**ME**	**LIE**	**NE**
Turbidity					
Solid waste contamination (Rubbish/debris)					
Contamination with fertilizer/pesticide residues from farming activities					
Industrial effluents pollution					
Surface water contamination					
Ground water contamination					
Algal blooms					
Changes taste of water					
Contamination by sewerage					
Siltation					
Others (specify)					

Section C: Impact of drought on Soil

1. Do you experience drought? Yes, No
2. If the answer is YES, how many times have you experienced drought in the last 5 years?

   ……………………………………………………………………………
3. Using the given scale, indicate the extent to which drought affects soil on your land as described by the items the table below:

Scale: No extent **(NE),** Little Extent (**LIE),** Moderate Extent (**ME**), Large Extent (**LE**), Very Large Extent (**VLE**)

Variables	**VLE**	**LE**	**ME**	**LIE**	**NE**
Soil erosion (by wind)					
Reduced soil productivity/					
Cracked soils					
Lots of dust generated by loose soils (bowl dust)					
Emergence of invasive species					
Compacting of the soil					
Loss of vegetation cover					
Loss of soil moisture					
Others (specify)					

Section D: Impact of drought on Water Sources

1. Are your water sources affected any time you experience drought Yes [ ] No [ ]
2. If the answer to the item above is "Yes", in what ways are they affected?

   a.…………………………………………………………………………………

   b.…………………………………………………………………………………

   c.…………………………………………………………………………………
3. Indicate the extent to which drought affects your water sources in the areas listed in the table below. Use the given scale

Scale: No extent **(NE),** Little extent (**LIE),** Moderate extent (**ME**), Large extent (**LE**) and Very Large Extent (**VLE**)

Impact	**VLE**	**LE**	**ME**	**LIE**	**NE**
Pollution (dust, dry objects etc.)					
Turbidity					
Reduced Water volumes the sources (rivers, lakes, water pans, dams)					
Drying water pans					
Drying river valleys					
Drying wells					
Lowered water table					
Loss of riparian vegetation					
Others specify					

Section E: Resilience- coping with Impacts of Floods on Soils and water sources

When afflicted by floods, do you engage in any activities to cope with the floods?

Yes [ ]No [ ]

If the answer is YES, how frequently do you actively engage in activities to cope with floods?

Never (N), Rarely (R), Occasionally (O), Often (OFT), Very often (VO)

Variables	**VO**	**OFT**	**O**	**R**	**N**
Floods on Soils					
Build gabions					
Use sand bags					
Contour Ploughing					
Clearing water channels					
Construct check dams and ponds					

Intercropping (trees and crops)					
Dig terraces to drain off excess water					
Use fertilizers					
Use organic manure/compost					
Planting trees on degraded soils					
Dig terraces to drain off excess water					
Floods on Water sources					
Build toilets well raised above the ground level					
Protect /secure drinking water collection points					
Use water filters to remove the silt					
Decontaminate drinking water					
Seal wells to avoid contamination					
Dig trenches round the well to allow runoff to bypass the well					
Treat water in boreholes and wells					
Wetland plants regeneration					
Spring head protection					
Not encroaching into the riparian land (30 m from the highest water mark)					
Use sand bags at river banks to prevent soil erosion					
Training on disaster management					

Section F: Resilience-Coping with Impacts of Drought on Soils and water sources

When afflicted by drought, do you engage in any activities to cope with the drought?

Yes [ ]   No [ ]

If the answer is YES, how frequently do you actively engage in activities to cope with drought?

Never (N), Rarely (R), Occasionally (O), Often (OFT), Very often (VO)

Variables	**VO**	**OFT**	**O**	**R**	**N**
During Drought					
Mulching					
Irrigation					
Paddocking (controlled grazing)					
Control free-range grazing/free grazing					
Agroforestry and planting hedges around the homestead					
Plant cover crops					
Plough soil to break the hard pans and allow decomposition of weeds and plant debris accelerated by high temperatures					
Planting drought resistant varieties of plants e.g. cassavas, pigeon peas etc.					
Water sources					
Filter water-use water filters					
Dig up sandy beaches for water					
Restrict/control abstraction					
Restrict/control grazing in wetlands					
Dredging (cleaning the well)					
Dig the well further-deepen					
Rehabilitate damaged river banks					

Widen drainage system					
Desilting drainage systems					

Section G: Resilience-Recovery from impacts of CCR Floods on Soils

1. Do you repair damages on your land caused by floods?   Yes [ ]   No [ ]
2. If the answer to item G1 is YES, state what you do to restore the land to its original status/usable status.
    a. ……………………………………………………………………………
    b. ……………………………………………………………………………
    c. ……………………………………………………………………………
    d. ……………………………………………………………………………
3. Rate your success in repairing damages on your land (soil) caused by floods listed in the below table. Use the given scale

Scale: Never successful (NS), Rarely Successful (RS), Occasionally Successful (OCS), Often Success (OS), Always Successful (AS)

Impact	AS	OS	OCS	**RS**	**NS**
Washed away top soil					
Solid waste contamination (mud and debris)					
Contamination with fertilizer and pesticide residues					
Gullies created by flood					
Leached nutrients in the soil					
Eroded vegetation cover					
Invasive species (e.g. striga)					
Waterlogging					
Soil and sediment contamination					

Reduced soils fertility (not a direct impact)					
Other (specify)					

Section H: Resilience-Recovery from Impacts of CCR Floods on Water source

1. Do you try to restore your water sources that have been affected by floods? Yes [ ] No [ ]

2. If the answer is YES state what you do to restore the water sources to the original/usable status
   a. ……………………………………………………………………………………
   b. ……………………………………………………………………………………
   c. ……………………………………………………………………………………
   d. ……………………………………………………………………………………

Rate your success in restoring your water sources affected by the effects of floods listed in the below table. Use the given scale

Scale: Never successful (NS), Rarely Successful (RS), Occasionally Successful (OCS), Often Success (OS), Always Successful (AS)

Variables	**AS**	**OS**	**OCS**	**RS**	**NS**
Turbidity					
Solid waste contamination (Rubbish/debris)					
Contamination with fertilizer/pesticide residues from farming activities					
Industrial effluents pollution					
Surface water contamination					
Ground water contamination					

Algal blooms					
Changes in taste of water					
Sewerage contamination					
Siltation					
Others (specify)					

Section I: Resilience-Recovery from Impacts of CCR Drought on Soils

1. Do you repair damages on your land caused by drought?

   Yes [ ] No [ ]

2. If the answer to item F1 is YES, state what you do to restore the land to its original/usable status

   a. ………………………………………………………………………………

   b. ………………………………………………………………………………

   c. ………………………………………………………………………………

   d. ………………………………………………………………………………

3. Rate your success in repairing damages on your land (soil) caused by drought listed in the below table. Use the given scale

Scale: Never successful (NS), Rarely Successful (RS), Occasionally Successful (OCS), Often Success (OS), Always Successful (AS)

Variables	AS	OS	OCS	**RS**	**NS**
Soil erosion (by wind)					
Reduced soil productivity					
Cracked soils					
Crop failure					
Lots of dust generated by loose soils (bowl dust)					

Emergence of invasive species					
Compacting of the soil					
Loss of vegetation cover					
Loss of soil moisture					
Others (specify)					

Section J: Resilience-Recovery from Impacts of CCR drought on water sources

1. Do you try to restore your water sources that have been affected by drought? Yes [ ] No [ ]

2. If the answer is YES, state what you do to restore the water sources to the original/usable status

   a. ………………………………………………………………………………

   b. ………………………………………………………………………………

   c. ………………………………………………………………………………

   d. ………………………………………………………………………………

3. Rate your success in restoring your water sources affected by the effects of drought listed in the below table. Use the given scale

Scale: Never successful (NS), Rarely Successful (RS), Occasionally Successful (OCS), Often Success (OS), Always Successful (AS)

Impact	**AS**	**OS**	**OCS**	**RS**	**NS**
Pollution (dust, dry objects etc.)					
Turbidity					
Decreased water volumes the sources (rivers, lakes, water pans, dams)					
Drying water pans					
Drying river valleys					
Drying wells					
Lowered water table					
Loss of riparian vegetation					
Others specify					

Appendix II: Direct Observation Guide.

The interviewer will make observations and confirm the following:

Section A: Resilience-Coping with **Impact of Floods on Soils**

1. Visible gabions on the farmlands
2. There are sandbags in place
3. The farmers practicing contour farming
4. There are debris in the water channels
5. Households have check dams /ponds for capturing excess water
6. There are trees planted on farmlands
7. Terraces have been dug in the farmlands
8. There are receipts of fertilizer purchase
9. There are packaging materials for fertilizers
10. There are compost pits in the households

Section B: Resilience-Coping with Impact of Floods on Water Sources

1. The toilets are raised above the ground?
2. There are visible signs of secured drinking water collection points
3. There are water filters in the homestead
4. The taste of chlorine can be picked in the water/a color comparator to measure residual chlorine
5. The trenches dug around the wells
6. The springheads are protected
7. Sand bags are visible at the riverbanks

Section C: Resilience-Coping with **Impact of Drought on Soils**

1. There are paddocks/is the land paddocked
2. Pipes for irrigation are laid down
3. Hedges and/or trees surround the homesteads
4. Ploughs or animals used for ploughing
5. The farmland is under crop cover

Section D: Resilience-Coping with **Impact of Drought on Water Sources**

1. There are water filters in the homestead
2. The households have a color comparator to measure residual chlorine
3. There are formal community arrangements or agreements controlling water abstraction
4. There is formal community arrangement or agreement on grazing in wetlands

Section E: Recovery from impacts of CCR Floods and Drought on soils and Water sources

Make observations on the evidence of measures to repair land and water sources from impacts of CCRDs (floods and drought). The respondents in questions 2 of sections G, H, I, and J question 2 of the household questionnaire will have mentioned the interventions being verified physically.

Appendix III: Key Informant Interviews guide: (KIG)

The KIG will take the format of the household questionnaire (Appendix 1). The interviewer will seek clarification from the key informant on the following:

1. To what extent do floods affect soils in this area?
2. To what extent do floods affect water sources in this area?
3. To what extent does drought affect soils in this area?
4. To what extent does drought affect water sources in this area?
5. Are there any attempts by affected households to cope with Impacts of Floods on Soils and water sources
6. Are there any attempts by affected households to cope with Impacts of Drought water sources?
7. In your opinion are the interventions taken against impacts of floods on soils successful? If not, why? And how can this be addressed?
8. In your opinion are the interventions taken against impacts of floods on water sources successful? If not, why? And how can this be addressed?
9. In your opinion are the interventions taken against impacts of drought on soils successful? If not, why? And how can this be addressed?
10. In your opinion are the interventions taken against impacts of drought on water sources successful? If not, why? And how can this be addressed?

Appendix IV: List of Key Informants

Name	**Profession**	**Designation**	**Location**
1. Paul Masanga	Public Health Officer	Sub-County Public Health Officer	Ahero
2. George Odhiambo Opetu	Technician	Weatherman	Ahero
3. Hawi Elvira	Environmentalist	Sub-County Environment Officer	Nyando
4. Emma Oginga	Technician	Sub-County Water Officer	Nyando
5. Robert Ouko	Environmentalist	Agribusiness Officer-	Nyakach Sub-County
6. Kenneth Mboya	Administrator	Chief	Lower Nyakach
7. Mary Gundo	Agrovet	Agrovet Shop Attendant	Ahero
8. Mary Nyamondo	Community volunteer	Flood Control Chairperson	Ahero
9. Raymond Oluoch	Administrator	Chief	Kakola
10 Johannes Makodia	Project Coordinator	World Vision	Katito Area
11. Caleb Obute Ogola	Agronomist	Sub County Agricultural Officer	Nyando
12. Erick Otieno	Field officer	Focal Coordinator	Nyando-Red cross
13. Dan Abuto	Environmentalist – Field Officer	Field and community Development Officer	VIRED International

Appendix V: Nyando Sub County Selected Crops Production in 2014-2018.

Crop	2014		2015		2016		2017		2018	
	Area (Ha)	Production (MT)	Area (Ha)	Production (MT)	Area (Ha)	Production (MT)	Area (Ha)	Production (MT)	Area (Ha)	Production (MT)
Maize	4,900	8,820	10,400	10,508	8,840	3,691	9,856	5,347	8,450	14,960
sorghum	3,255	4,393	6,950	9,383	6,358	3,432	6,458	6,996	8,350	15,000
Rice	1,180	10,620	2,320	9,280	2,343	9,372	3,000	10,080	2,590	13,000
Beans	2,630	3,550	4,130	3,717	4,470	961	4,560	3,672	4,190	3,760
G/grams	490	441	3,150	1,418	2,512	676	2,780	715	2,520	2,270
S/potatoes	512	922	295	2,950	87	870	625	9375	355	3,500
Cassava	410	738	277	5,355	55	316	1,050	8,100	565	6,710

Source: Office of the County Director of Agriculture County Government of Kisumu (2019)

Appendix VI: Cronbach's Alpha Test

Reliability test SPSS outputs

Case Processing Summary			
		N	%
Cases	Valid	6	27.3
	Excluded[a]	16	72.7
	Total	22	100.0
a. Listwise deletion based on all variables in the procedure.			

Reliability Statistics	
Cronbach's Alpha	N of Items
.880	114

Appendix VII: NACOSTI Research Permit

THIS IS TO CERTIFY THAT:
MS. ROSELYN AGUMBA ONYURO
of KABARAK UNIVERSITY, 0-20117
NAIVASHA,has been permitted to
conduct research in *Kisumu County*

on the topic: *ASSESSMENT OF COMMUNITY RESILIENCE TO IMPACTS OF CLIMATE CHANGE RELATED DISASTERS ON THE ENVIRONMENT IN LOWER RIVER NYANDO BASIN, KISUMU COUNTY, KENYA*

for the period ending:
14th March,2019

Permit No : NACOSTI/P/18/29035/21639
Date Of Issue : 14th March,2018
Fee Recieved :Ksh 2000

....
Applicant's Signature

....
Director General
National Commission for Science, Technology & Innovation

Appendix VIII: NACOSTI Research Authorization Letter

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone:+254-20-2213471, 2241349,3310571,2219420
Fax:+254-20-318245,318249
Email: dg@nacosti.go.ke
Website : www.nacosti.go.ke
When replying please quote

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/18/29035/21639**

Date: **14th March, 2018**

Roselyn Agumba Onyuro
Kabarak University
Private Bag - 20157
KABARAK.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Assessment of community resilience to impacts of climate change related disasters on the environment in Lower River Nyando Basin, Kisumu County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Kisumu County** for the period ending **14th March, 2019.**

You are advised to report to **the County Commissioner and the County Director of Education, Kisumu County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kisumu County.

The County Director of Education
Kisumu County.

Appendix IX: List of Academic Publications

1. Roselyn Agumba Onyuro, Jackson John Kitetu, Paul M. Makenzi & Dr. Eliud Gary Michura (2019). Impact Of Climate Change Related Disasters On The Resilience Of Households In Nyando And Lower Nyakach Sub County, Kisumu County, Kenya. *BEST: International Journal of Humanities, Arts, Medicine and Sciences (BEST: IJHAMS) ISSN (P):* 2348–0521, ISSN (E): 2454–4728 Vol. 7, Issue 11, Nov 2019, 9–20 © BEST Journals
2. Roselyn Agumba Onyuro, Jackson John Kitetu, Paul M. Makenzi, Dr. Eliud Gary Michura (2020). The Nexus between Socio-economic Factors and Coping with Effects of Climate Change Related Disasters on the Environment in Kisumu County. *Merit Res. J. Environ. Sci. Toxicol.* 2020 6(3): 058-0660