SOCIO-ECONOMIC DETERMINANTS OF INTEGRATED FLOODS MANAGEMENT FOR VULNERABILITY REDUCTION IN KANO PLAINS, KISUMU COUNTY, KENYA

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (INTEGRATED WATERSHED MANAGEMENT) IN THE SCHOOL OF PURE AND APPLIED SCIENCES, KENYATTA UNIVERSITY

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DECLARATION

This thesis is my own original work and has not been submitted for any other degree in any University.

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DEDICATION

This work is dedicated to my mother; Mrs. Tryphose Odero, my late father John Odero, and late brother Stephen Okello and all my siblings.

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ACRONYMS AND ABBREVIATIONS

DEM	Digital Elevation Model
DMC	Disaster Management Committee
EC	European Commission
FGDs	Focus Group Discussions
GIS	Geographic Information System
ICWE	International Conference on Water and the Environment
IFM	Integrated Flood Management
IWM	Integrated Watershed Management
LBDA	Lake Basin Development Authority
NEMA	National Environment Management Authority, Kenya
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Program
SUSWATCH	Sustainable Watch
VIRED	Victoria Institute for Research on Environment and Development

OPERATIONAL DEFINITIONS OF TERMS AND CONCEPTS

Community Participation: The process where communities converge for a common course.

***Flood*:** A temporary covering of land by water under specified conditions.

Flood Hazard: Refers to danger posed to people, property, and the environment as a result of inundation.

Flood Management: Interventions aimed at minimizing the negative impacts of floods.

Flood Risk: The probability of negative effects to human population resulting from flooding.

Flood Vulnerability Index: The degree of susceptibility to flooding.

IFM Adoption: The roll out and uptake of Integrated Flood Management in flood prone areas.

Integrated Flood Management: Strategies engaging communities and other stakeholders in a consultative manner to manage floods.

Mental Map: Community generated maps of flood prone areas based on their perceptions and past floods experiences.

Participatory GIS: The use of Geographic Information Systems (GIS) to involve people in planning and design decisions, using their spatial knowledge and discussion of virtual or physical, two or three-dimensional maps and visualization aides.

Slope Vulnerability: Refers to the measure of slope as an influencing factor to floods.

Socio-economic Determinants: Societal factors that influence the degree of response to floods.

Soil Vulnerability: Refers to the measure of soil as an influencing factor to floods.

Vulnerability Reduction: Interventions and initiatives geared towards minimizing or mitigating risks resulting from floods.

ABSTRACT

For several decades floods have continuously threatened communities' livelihoods and caused destruction to properties and the ecosystem as a whole. In an attempt to minimize the destructive nature of these events, different flood mitigation strategies have been employed. Nevertheless, the challenge with these strategies employed is that they seldom give audience to the affected people, instead focusing on technical solutions. Of importance is the integrated floods management approach which puts local knowledge into consideration. Although some studies have emphasized the need to have this incorporated with technical expertise in order to get more lasting solutions to the negative flood effects, much work still needs to be done. This study was conducted in the Nyando sub-catchment, Kano Plains in Kisumu County, Kenya. The study addressed the following specific objectives: (i) To establish the flood risk areas of Kano plains in Nyando sub-catchment (ii) To assess the socio-economic determinants of community vulnerability to floods in flood risk areas (iii) To determine the effects and vulnerability of flood events in flood risk areas and (iv) To evaluate the effectiveness of existing mitigation measures for flood management. The study utilized both qualitative and quantitative methodologies. Stratified sampling technique was used to select the three flood prone areas in Kano Plains, namely, Nyando, Miwani and Lower Nyakach as study sites. Simple random sampling technique was then used to select 100 households for the survey. Purposive sampling was used to select the key informants. Methods of data collection included questionnaires, key informant interviews, focus group discussions (FGDs), GIS-integrated participatory community mapping and desk reviews. Weighted analysis was done for the land cover, DEM, soil and river datasets as corroborative data for the community identified flood risk areas. Descriptive statistics was used to analyze the questionnaires, and the qualitative data from key informant interviews was analyzed using content analysis method. FGDs recordings were transcribed and analyzed thematically using NVIVO software. The main research findings were that 65.93% of respondents in this study live at the downstream of river Nyando, of which 60.00% resided in Nyando Sub County, thus exacerbating the risk to floods. Secondly household income was found to be the most significant factor with a likelihood ratio of $p=0.026$, in determining flood vulnerability the other factor was type of housing with a likelihood ratio of $p=0.002$. Thirdly, loss of farmland (17.98%), houses and property (69.66%) were considered the most serious effects of floods. Fourthly, 100% of the respondents agreed that construction of dykes/dams was a very effective flood mitigation measure. The study therefore concludes that socio economic determinants such as household income, household size and type of housing have a significant role in determining household vulnerability to floods. The study recommends an integrated approach to floods management through government led initiatives that incorporate local knowledge. Finally, the watershed managers must prioritize activities and interventions such as policy changes that will help effectively use and manage flood plains.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

For local communities, particularly those living in flood plains across the globe, there has been a notable change in inundation patterns over the decades in terms of their frequency, intensity, and their predictability (Terumoto 2006). UN-Water (2011) reports that floods have caused about half of the disasters worldwide with 84% of such disasters causing deaths. Aloysius (2012) states floods as one of the most devastating natural hazards of the world with major loss of lives of human beings; destruction of socio-economic infrastructure supporting supply of water, electricity, as well as roads and railways. These floods also contribute to the spread of diseases like diarrhea, typhoid, scabies, cholera, and malaria. Current disasters are becoming more complex and climate change presents a greater chance for even worse impacts (Aalst and Burton, 2002). Aalst and Burton, 2002, further realize that degradation of the natural environment has often been mentioned as a natural hazard risk factor, although little has been done in terms of policy formations to tackle the challenge. Urama and Ozor (2010) noted that sub-Saharan Africa has often reported cases of floods, and this has been mainly due to climate change, which has led to the loss of lives and property worth billions of dollars. The main reason for this being poor planning for such incidences.

Integrated Watershed Management (IWM) is an important strategy in ensuring communities continue to gain from resources within their watershed; it involves methodologies that engage many interested parties to harvest and utilize water from the floods for livelihood support in flood prone areas (Ongor, 2000). To minimize disasters and to recover the local community to its previous state, integration of local knowledge with the institutions to empower the local community and to gather local knowledge on disasters to develop a cyber-based geographical information system is required (Senanayake *et al*., 2003). Forrester (2003) defined Participatory Geographic Information System (PGIS) as the most useful tool for extracting local knowledge, perceptions of environmental problems and hazards, and presenting and communicating it to environmental scientists. He further noted that citizen maps have the clarity and conciseness that allows decision makers to take into account community inputs which used to be ignored. Weiner and Harris (2003), similarly noted that in seeking land reforms in South Africa, Public Participation GIS (PPGIS) should not be conceptually, empirically, or politically disconnected from core GIS and Society concerns. IFAD (2009) recognized that PGIS uses methods, such as mental mapping, participatory sketch mapping, transect mapping, and participatory 3-dimensional modeling. All these methods are commonly associated with Participatory Learning in Action (PLA) initiatives. Nyakundi (2010) also identifies a focus to sensitization and broad-based community involvement in flood risk interventions as some global efforts to combat flooding.

Kenya has had serious floods and drought disasters throughout the nation causing major destructions and even causing deaths in some instances, (Flood Mitigation Strategy, 2009). Natural occurrences including flash rainfall, river floods and coastal floods often lead to serious hazards (National Environment Management Authority, 2004). Certain incidences of floods sometimes are a result of human induced factors such as deforestation, interference with watersheds and areas prone to floods. For instance, floods have as well occurred along some basins having average rainfall as a result of excess runoff triggered through human activities such as land clearance for cultivation and general degradation upstream. There is diverse hydrological response of Kenyan rivers to both geomorphic characteristics and hydrological factors in the river basins (NEMA, 2004). This causes an influx in the manner in which floods happen in major rivers such as Nzoia, Tana, Athi, and Nyando (NEMA, 2004).

A major cause of floods in River Nyando is due to bursting of the banks as a result of the river overflowing (Olang and Furst, 2011). This is a frequent occurrence in the long and short seasons of rain. The upstream of river Nyando are in Kericho and Nandi Counties which experience high precipitation annually; it is this rain which results in most serious floods in the basin (Olang and Furst, 2011). Also contributing to the floods are the flat topography, deforestation and black cotton soils within the watersheds that prevent rapid infiltration, which increase surface runoff (Onyango *et al*., 2005). The problem is aggravated through gulley erosion and poor land-use practices (Onyango *et al*., 2005). The current study analyzed socio-economic determinants for integrated flood management in the study area. The study also involved participation of local communities in order to determine sustainable measures for flood management.

1.2 Statement of the Problem

Since floods have been a frequent occurrence in Nyando river basin, this has substantially caused degradation in the area. Nyando River passes through Kano Plains and traverses a wide area of the lower Kano Plains, which is prone to frequent flooding. Such floods normally cause psychosocial problems, poses danger to health, disrupts settlements and infrastructure, causes food insecurity due to losses on farms, and a general malaise of the population, as a result hindering any type of development of this high potential Kano

Plains (Opere, 2013). Vella (2012) states that in 2009, 1126 people (206 households) lost their houses and an additional 3,000 people were affected in various ways by the floods, schools were destroyed and subsequently closed, diseases associated with floods such as cholera breakout was recorded and about 2,000 farmers' crops got washed off in Kano Plains.

The upstream of Nyando River basin, which is known for rejuvenation of water resources, has been depleted as a result of human activities such as clearance of land for settlement or agriculture. More discussion over the likely effects of this degradation of the basin is still ongoing (Acheing *et al.*, 2020). Nyando River has its source in Kericho and Nandi Counties, and both Counties have an altitude of over 2000m above sea level and a mean annual rainfall of between 1800mm and 2000mm (Michella et al., 2019). Nyando River basin is more sharply characterized upstream, however on reaching the plains, close to Lake Victoria, the tributaries disperse as a result of periodic deposits, that lead to overflow of the banks before ending in the wetlands near the lake (Olang *et al*., 2009, Guya 2019), and this appears to accentuate the intensity of floods in the area. The general objective of this thesis was therefore to analyze socio-economic determinants for integrated flood management, with a view of reducing vulnerability of the resident communities. It was also aimed at determining sustainable flood mitigation measures in the study area.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study was to analyze socio-economic determinants for integrated flood management for vulnerability reduction in Kano Plains in Kisumu County, Kenya.

1.3.2 Specific Objectives

To address the above general objective, the study focused on the following specific objectives:

i. To establish flood risk areas of Kano Plains in the Nyando sub-catchment.
ii. To assess the socio-economic determinants of community vulnerability to floods in the flood risk areas of Kano plains.
iii. To determine the effects and vulnerability of flood events in flood risk areas in Kano Plains.
iv. To evaluate the effectiveness of existing mitigation measures for flood management in Kano Plains.

1.4 Research Questions

The study addressed the following research questions:

i. Which are the flood risk areas in Kano Plains in the Nyando sub-catchment?
ii. What are the socio-economic determinants of community vulnerability to floods in the flood risk areas of Lower Kano plains?
iii. What are the effects and vulnerability of floods events in flood risk areas in Kano Plains?
iv. How is the effectiveness of existing mitigation measures for flood management in Kano plains?

1.5 Justification and Significance of the Study

Lower Kano plains is among the areas in Kenya mostly prone to floods. River Nyando has demonstrated hydrological vulnerability for several years and therefore presented an area of focus for this study. The study adopted an integrated flood management approach since this was found to be relevant. This approach provided an opportunity to combine both technical and indigenous knowledge for flood mitigation. Only few researches on floods done in Nyando have focused on IFM as an option for flood mitigation; and this is part of the justification for this study. It was also important to understand the differential vulnerability to floods in relation to the socio-economic dynamics of the community and their local knowledge and the spatial vulnerability realized using the GIS technique.

The results obtained from this study will help the communities living in Kano Plains to sustainably deal with flood events. In addition, the results will assist the Kenya government to apply the same measures in other areas of the country with similar flood challenges. The results will also be useful to scholars and other organizations involved in flood management studies as reference material.

1.6 Scope and Limitations of the Study

The study analyzed socio-economic determinants for integrated flood management, in order to reduce vulnerability of the communities in the study area. The determinants considered were cultural and livelihood factors, including age, sex, income, household size, period of stay in the area, as mechanisms of integrated flood risk and vulnerability reduction. This thesis focused on the three sub- Locations in the lower reaches of River Nyando in lower Kano Plains namely, Nyando, Miwani and Lower Nyakach as the study area. One challenge experienced during the study was the unwillingness of respondents to participate fully; and to address this challenge, the researcher engaged two research assistants that understood the study area and were also native language speakers to help with data collection. The limitations faced during the study were mainly inadequate time and resources. However, the researcher made the best use of the available time and resources to achieve realistic results.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter reviewed the literature that was relevant for this study. This review focused on topical thematic issues related to the study objectives. This chapter also looked at the theoretical and conceptual frameworks, the former upon which this study was anchored, and the latter which provided the conceptual underpinnings for the analysis.

2.2 Floods as a Hazard

One of the most overwhelming and frequently occurring natural hazards globally is flooding. Due to the damages it leaves behind, flooding remains a significant topic in the world today. Damages caused by this hydrological hazard ranges from socio-economic damages to loss of lives and properties (Komolafe *et al*, 2015). Between 1995 and 2015, The United Nations Office for Disaster Risk Reduction (UNISDR) and the Belgian-based Centre for Research on Epidemiology of Disasters (CRED) stated flooding had the highest percentage of natural disasters by disaster type with 3062 occurrences (43 percent). This report revealed further that in the past two decades, there have been 157,000 deaths from floods globally. The report also says that 3062 flood disasters affected 2.3 billion people all over the world between 1995 and 2015, accounting for 56 percent of all those affected by weather-related disasters (Floodlist 2016). Likewise, 290 flood-disasters were reported in Africa, with 23 million people affected and 8,183 dead; this also caused economic losses of $1.9 billion between 1996 to 2005 (Musungu and Motala 2012).

There is a rise in global awareness for mitigation measures to flood damage due to the observed escalation in magnitude, frequency, and intensity of flood events worldwide (Hall *et al.*, 2014). Most of these efforts have focused on quantitative methods of flood mitigation. However, this study employed a participatory approach to flood mitigation by engaging the local community in this research.

2.3 Socio-economic Determinants for Integrated Flood Management

According to Flood Mitigation Strategy (2009), opportunities for effective integrated flood management should enable the government to realize that vulnerability is heightened by several physical factors such as; the degree of protection from flood hazards, the quality of available infrastructure, the level of access to relevant resources, and the capacity to avoid, withstand or recover from flood hazards. In addition, other socio economic factors such as poverty, overpopulation, level of education, gender, poor land-use practices, and absence of flood mitigation mechanisms also heighten the vulnerability of the population to floods. For instance, women are forbidden from owning land in some cultures and this prevents them from making important decisions on issues regarding land (Nethengwe, 2007).

Many affected people are neither aware of some coping strategies used elsewhere. However, sufficient knowledge and capacity is available in the country for flood management, and this can also address the country’s social, economic and other development policies (Flood Mitigation Strategy, 2009). This study sought to explore existing opportunities, by applying integrated flood management (IFM) approach. This approach considered various organizations and/or institutions, socio-economic activities in the area, geomorphology (geology and slope), and precipitation as variables for effective adoption of IFM.

2.4 Effects and Vulnerability of Flood Events in the Flood Plains

The value of water in the survival of species and for the function of the natural environment cannot be overemphasized (Navarro-Ortega *et al*., 2015). Realizing its qualitative and quantitative roles in human health and in socio-economic development is easy. Flooding causes more deaths, economic loss and social destruction than any other type of natural hazards worldwide (Messner & Myer, 2006). Soya (1998) stated that in Eastern Africa, Somalia and Kenya had experienced exceptionally heavy rains that brought varying flooding events; and these floods led to severe damage to crops in the field and in stores, and loss of a large number of livestock.

According to Kenya's Ministry of Finance and Planning (2002), among the worst devastating effects of floods are; increased waterborne diseases, destructions of farms and property, loss of infrastructure, difficulty in transportation, and learning interruptions. Flood Mitigation Strategy (2009) indicated that about 5,000 people in Kano Plains were affected by floods every year. On an average, Ksh.49 million worth of damage is experienced annually with relief and rehabilitation measures costing Ksh.37 million.

2.5 Institutions Handling Floods in Kano Plains

A number of institutions in the Ministry of Water mandated to handle floods were found to work in Kano Plains, the main ones being the National Water and Pipeline Corporation and Water Resources Authority. Japan International Corporation Agency has been key in flood mitigation in the area. Others include Swedish International Development Agency (SIDA), Danish Development Agency (DANIDA) and the World Bank at the National level, which worked on the "Operationalization of the Water Act 2002 in Water Resources Management" JICA, 2009.

There is a Disaster Management Committee consisting of various institutions and departments whose work is to coordinate disaster management efforts. The chair of the committee is the representative of the office of the President at the Sub County, JICA, 2009.

2.6 Integrated Flood Management Approach to Flood Risk Mitigation

Integrated flood mitigation requires involvement of the local community as key stakeholders. In recent past, a gap has been realized in the normal top-down approach to problem handling. Halbe *et al.*, (2018) study show the growing importance of the ecosystem-based and stakeholder involvement paradigms which has led to the consideration of a range of regulating and cultural ecosystem services that had previously been neglected. A number of statutory frameworks have emphasized the need to involve various stakeholders all through environmental management including Flood Risk Management (ICWE, 1992; UNEP, 1992; UNECE, 1998; EC, 2000, 2003, 2007). Reed *et al*., 2009, reiterates the need of analyzing stakeholders through identifying those with vast knowledge needed to meet the goals of the participatory process.

Technical knowledge by itself is not enough to make sound decisions concerning specific local contexts (Douglas *et al*., 2010). It is instead, widely accepted that embracing participatory paradigms is more desirable in many decision-making processes since it enables the technical experts and the community members with a breadth of knowledge on the matter at hand to be well engaged in co-producing knowledge necessary to inform decisions (Callon, 1999). This kind of knowledge need not be mutually exclusive. Combining community knowledge with contemporary techniques to record, organize and evaluate risk related data is a way of engaging and mobilizing community capacity (Phong *et al*., 2008).

Integrated floodplains management that focuses on geomorphology has been found to be successful in large river basins both in Europe and North America (Hudson *et al*., 2008). This has been done in US, in California in Sacramento and San Joaquin; Missouri basin (Missouri); in Red basin (Manitoba and Minnesota); in Mississippi basin (Louisiana); and Kissimmee basin (Florida). In Europe, it has been done in Ebro basin (Spain); Rhone basin (France); Rhine basin (The Netherlands); Danube basin (Romania); and Volga basin (Russian Federation) (Hudson *et al.* 2008).

Berkes (2009) states that Participatory Resource Management (PRM), which is also known as 'co-management', is a knowledge integration between governmental stakeholders and local resource where sharing of power and responsibilities is allowed in a management process. It has been realized that leaders and people in power only effectively respond to communities especially if they contain a huge number of potential voters (Grant and Omdahl, 1993). The planners emphasize public participation, including community organizations since they acknowledge the importance of community input in local issues. The planners also agree that solutions developed by communities are more practical, feasible, realistic, and sustainable, as compared to other methods.

2.6.1 Traditional Knowledge in Floods Management.

The UN General Assembly in 2003 adopted resolution 58/124 which specifies that there is a need for enhancing education regarding the use of indigenous knowledge for disaster risk reduction. Global Change Research in Africa (2012), emphasized that the need to incorporate more of these traditional knowledge on disaster reduction as normal top-down approaches are not enough. Danladi (2019) explains the danger of extinction some of these indigenous knowledge on flood early warning signs, response and coping techniques peculiar to any particular given region are facing. He further gives examples used such as the understanding of cloud types, conduct of reptiles, wind movement, feathered creatures and insects as some illustrations employed to detect flood early warning signs.

2.7 The use of Participatory GIS in Flood Risk Mapping

The residual risk of flood hazard needs to be seriously taken into consideration. This should involve local planning and precaution, including flood protection strategies. Since flood hazards and vulnerability are not continuous events, there should be corresponding analyses and production of up to date maps, after significant changes with minimal expenses (B¨uchele *et al*., 2006). Vulnerability related to floods often amounts to the level of risk over socio-economic support systems of a community (Cannon, 1994). However, approaches to flood mitigation should normally be based on a holistic assessment of the flood risk, and an accurate analysis of uncertainties related to assessment techniques (Apel *et al*., 2004). Flood hazards result from natural events, and these often lead to tragedies which are associated with complex socio-economic, political, and environmental processes (Flood Mitigation Strategy, 2009).

Therefore, communities’ role in the identification and recognition of areas prone to floods is very important. By using FGD forums, participants can interact with each other, thus indicating coping mechanisms and strategies, as well as the importance of social networks (Nethengwe, 2007). Forrester (2003) stated that Participatory GIS (PGIS) evolved from conventional GIS, which was seen to be all about modern science, and gave power to the "experts" instead of the people. Therefore, PGIS was considered as the best tool for environmentalists to realize affordable, efficient and timely solutions, and to accommodate the views of communities affected by disasters and hazards (Forrester, 2003). PGIS therefore aids in visualizing flood vulnerability, by combining mental maps generated by the community with spatial information from the "expert". This study applied the PGIS concept by engaging the community in mental mapping of areas prone to floods and comparing their findings with the traditional GIS based flood vulnerability maps.

2.8 Summary of Key Literature Reviewed and Identified Knowledge Gaps

The following represents a summary of key knowledge gaps found from literature reviewed above.

Table 2. 1 Key Literature Reviewed and Identified Knowledge Gaps

Author and Year	**Title of Research**	**Summary of findings**	**Research Gaps**
Douglas *et al.* (2010)	**Urban pluvial flooding: a qualitative case study of cause, effect and nonstructural mitigation.**	**Victims of the floods were unprepared, ill-informed and confused as to responsibilities before, during and after the event.**	**A lack of community involvement in flood risk mitigation.**
Olang *et al.* (2011)	Effects of land cover change on flood peak discharges and Run-off volumes: model estimates for the Nyando River Basin, Kenya.	Right land use choices minimize losses due to floods.	Research mainly focused on land use management without considering other biophysical factors such as slope, drainage network and soil.
Hall *et al.* 2014	Understanding flood regime changes in Europe: A state of the art assessment.	A rise in awareness on flood mitigation measures due to the observed escalation in magnitude, frequency, and intensity of flood events.	Research focused purely on quantitative scientific methods of floods prediction without interrogating the socio economic influences of floods mitigation.
Nethengwe, 2007	Integrating Participatory GIS and Political Ecology to study Flood Vulnerability in the Limpopo Province of South Africa	There is a significant change in flood coping strategies in households, with regards to apartheid	There was little focus on traditional GIS and its attributes for flood risk mapping.

Source: Author, 2019

2.9 Theoretical Framework

The study was informed by the theory of community participation. Stone, 1989 defined community participation approach in development as "to design development in such a way that intended beneficiaries are encouraged to take matters into their own hands, to participate in their own development through mobilizing their own resources, defining their own needs and making their own decisions about how to meet them". Khwaja, (2004) explains the need to have a balanced community participation process that will not lead to worse project outcomes. In Integrated Floods Management, the approach is similar in that the views of community as key stakeholders are considered important.

2.10 Conceptual Framework

In IFM, the first concept involves envisioning what the river basin should be. The second idea is to incorporate sustainable livelihoods opportunities to improve performance of the system holistically (World Meteorological Organization and UNEP 2004). Opperman *et al*. 2009 explains how easy it is to reduce human vulnerability by limiting exposure to flood hazards from a single-objective perspective, a true picture of the complex dynamic interaction between biophysical and human factors is what bridges the gap in vulnerability and resilience.

The current study adopted a conceptual framework that combines conventional/traditional GIS data sources such as land use patterns, slope, soil, stream network, and administrative boundaries with community local knowledge generated through mental mapping as "independent variables" interacting with intervening variables such as human interactions, Participatory GIS, to reduce risk, vulnerability and build resilience as outcomes/ dependent variables. This approach was adopted in the PGIS database to analyze differential flood vulnerability among the local communities, Grabs *et al.* 2007.

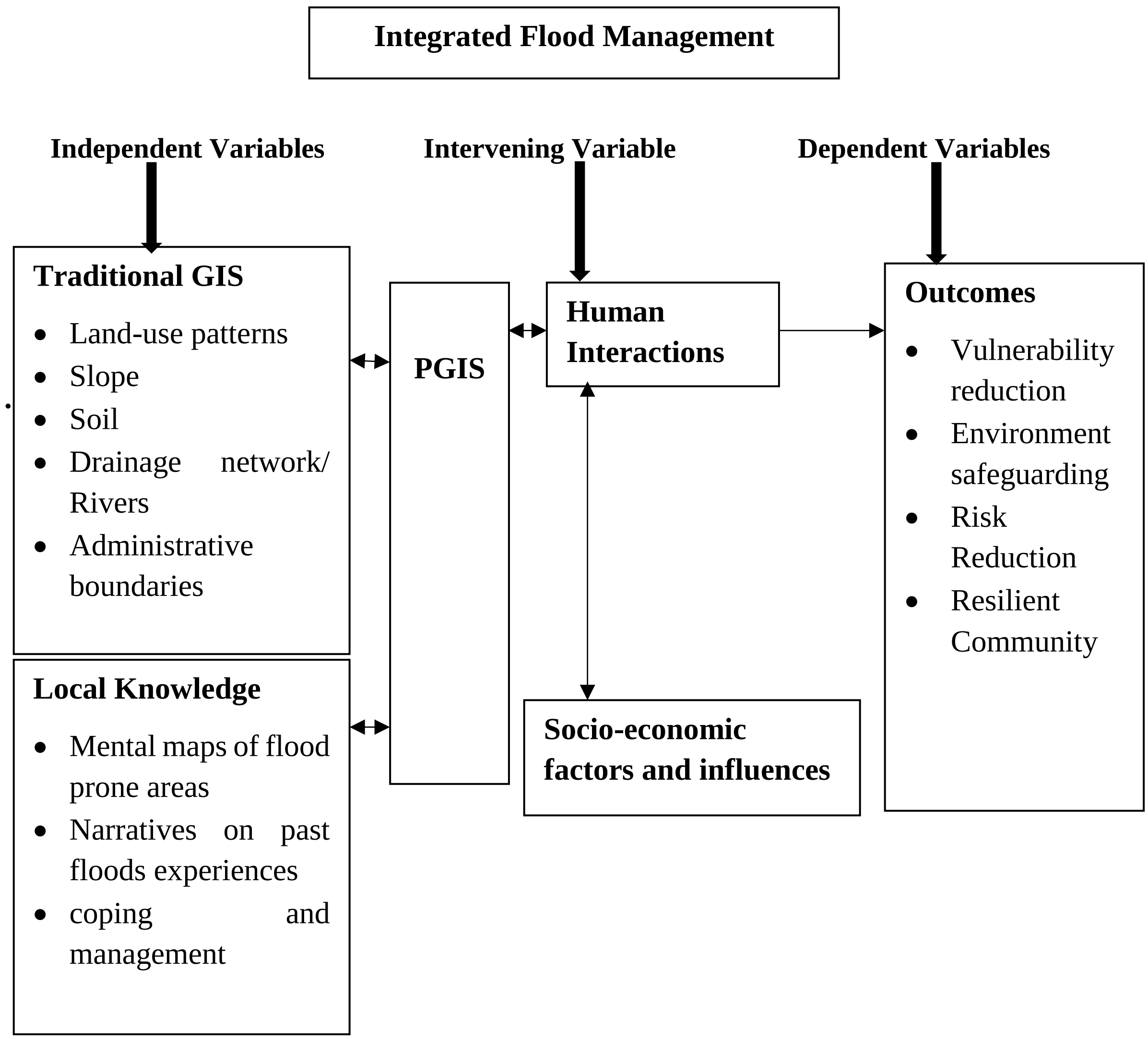

Figure 1. 1 PGIS Model Linking GIS to Local Knowledge for Flood Vulnerability Mapping

(Source: Adopted and modified from Nethengwe (2007)

CHAPTER THREE: MATERIALS AND METHODS

3.1 Introduction

This chapter presents a description of the study area, highlighting the study location, population, socio-economic characteristics and topography. It also gives the research design, the sampling procedure, research instruments, methods of data collection and analysis.

3.2 Research Design

This study adopted a descriptive research design, which involves describing the characteristics of a phenomenon and collection of information through interviewing or the administration of questionnaires to a selected sample size. Descriptive design is useful for extensive research, and is not only convenient for fast data collection but also ensures a high level of confidentiality (Orodho, 2003). Descriptive design was chosen because it helped in the collection of data from the respondents spread across the study area. The study used the procedure of Rea and Parker (2014), due to its ability to bring out issues important for development and management of human resources and their expectations.

3.3 Study Area

This research was carried out in the Kano Plains in Kisumu County, Kenya (Figure 3.1). The study focused on three sites in Kano plains, namely Nyando, Miwani and Lower Nyakach. Kisumu County is bordered by Nandi County and Nandi Hills to the North, Kericho County to the East, and Homa Bay County to the South, and Nyabondo Escarpment to the South-East (NEMA, 2004; LBDA, 1992; Republic of Kenya, 2001).

Kano Plains is located between longitudes 43^0 and 35^0 50' E and latitudes 1^0 30'N and latitude 0^0 and 05'S (NEMA, 2004).

The Nyando basin has various land use characteristics, largely influenced by rainfall patterns and socio-cultural practices (Olang and Fürst, 2011). Main soil type in the area comprise vertisols, which is used to grow sugarcane, rice and cotton. However, there is a significant reduction in total cotton production and per hectare (WMO and UNEP, 2004). The floodplain has minimal rainfall, with mean annual rainfall ranging between 800 mm and 1200 mm. However, the northern and southern parts of the basin experience more than 1600 mm respectively. Most of the rainfall is experienced in the north in Nandi Hills, and this gradually reduces towards the southeastern side (WMO and UNEP, 2004). A peculiar characteristic of Nyando floodplains are the frequent floods aggravated by human activities due to the growing human population (Olang and Fürst, 2011). The rapidly expanding number of people in the basin is the main reason behind the majority of the land cover dynamics (Olang and Fürst, 2011). The upper catchment is mainly thick forests (for example., Tinderet Forest), whereas the middle catchment has, scattered trees and grass, as a result of clearing, cultivation and burning due to human settlement (Opere, 2013).

3.3.1 Socio-economic Activities in Kano Plains

The lower parts of Kano Plains consist of large scale sugarcane plantations, food crops growing which depends on rainfall, and rice production (irrigation and rain-fed), as well as cattle grazing. In the farmed land, various crops (maize, sorghum, finger millet, rice, green grams, cowpeas, ground nuts, sweet potatoes, tomatoes, onions, kales, sugarcane, cassava and cotton; in addition are varieties of local vegetables, fruits such as mangoes, citrus, avocadoes, pawpaw and bananas) are grown. Fishing is also done, although on small scale (NEMA, 2004).

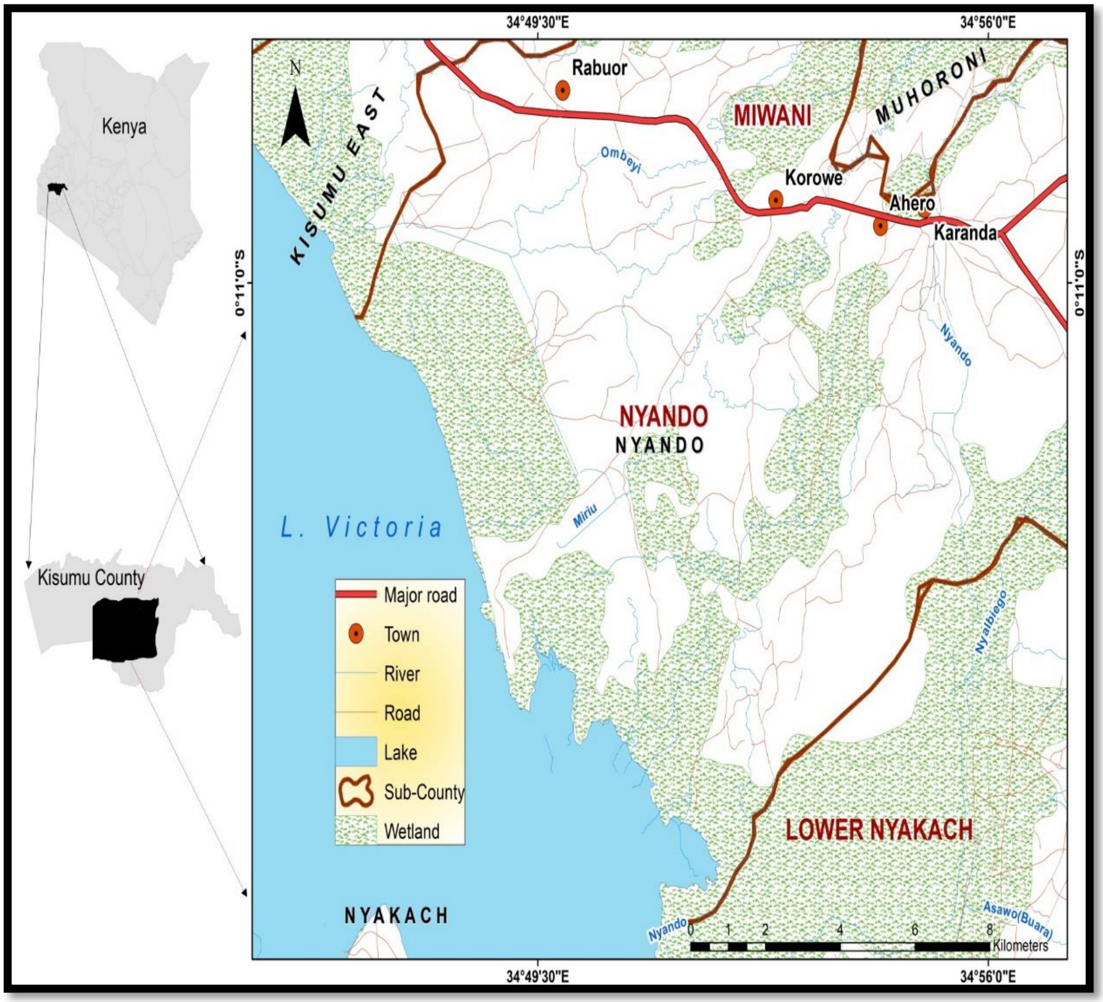

Figure 3. 1: Lower Kano Plains (Source: Adopted from RCMRD Geoportal (Source: Adopted from RCMRD Geoportal (2019)

3.4 Target Population

The total population of the three study sites was 305,799 (KPHC 2019) all of which were of interest in this study because they were the ones directly affected by the flood hazards and whose livelihoods were being disrupted. The household heads were the ones interviewed in the survey. Also considered in the study as key informants were administrative heads of the sites, County Government officials, National Government officials, and Non-Governmental Organizations officials, since they provided a balanced assessment on the vulnerability factors, resilience and coping mechanisms in the flood risk areas.

3.5 Sampling Procedures and Sample Size

Stratified sampling technique was employed in this study to select the three study sites namely, Nyando, Miwani and Lower Nyakach which served as the strata where the 100 households sample was drawn. Simple random sampling technique was used to select the 100 households that participated in the study, and this was based on their proximity to river Nyando and its tributaries; while purposive sampling technique was used to select the key informants. The sample size proportional distribution per study site is as shown in Table 3.1. All key informants were 10 in number, 3 administrative heads, 4 Government officials and 3 NGO's officials.

The sample size was calculated from a total of 305,799 people in the three study sites, using Yamane (1967) formula.

$$n = \frac{N}{[1+N\ (e)^2\ ]} \qquad (\textit{Equation 1})$$

where;

n = Sample size

N = population size

= margin of error

The formula is useful in places with known populations; and the sample size obtained was:

Population size (N) = 305,799

Margin of error (e) = 10 percent

N = 305,799/1+305,799 $(0.1)^2$

n = 99.95

n = approximately 100 respondents which were proportionately distributed in accordance to the individual populations in each of the three study sub locations (Table 3.1).

Table 3. 1: Sample Size Distribution in the three Study Sites

Sub Location	Sample size	Population	Percentage (%)
Miwani Sub Location	**30**	**90,873**	29.71
Nyando Sub Location	**53**	**161,508**	52.82
Lower Nyakach Sub Location	**17**	**53,418**	17.47
Total	**100**	**305,799**	**100.00**

Source: Adapted from KNBS (KPHC 2019)

The sampled households to which questionnaires were administered were randomly selected from Miwani, Nyando and Lower Nyakach Sub Locations.

3.6 Research Instruments

The research instruments used for data collection in this study were; questionnaires, key informant interviews, focus groups discussions (FGDs), direct observation, Satellite images, community mental mapping, relevant topographical maps and publications.

3.7 Pilot Study

A pilot study was conducted prior to the main study in order to test the research instruments such as the questionnaire and ascertain the relevance of the questions and their validity. Two research assistants were nominated and trained by the researcher on the procedures of data collection and research ethics. Fluency in English, Swahili and Luo languages was one criteria used to select the research assistants. Their training involved interpretation and understanding of each question in the questionnaire with reference to the study.

The pilot study involved a sample of 10% of the total sample with similar characteristics. Ten (10) household members of Lower Nyakach were selected randomly for the testing; however, these were not part of the final study. This aided in the validation of the instruments by studying responses given and assessing how the respondents understood the questions. This was an important exercise as it revealed vague questions and helped minimize ambiguity in the questions. Furthermore, it helped the study get important comments and inputs from respondents which improved efficiency of the research instruments, and helped in adjusting the strategies and approaches to achieve high response rates in the actual research. The exercise was guided by results from similar studies.

3.8 Validity and Reliability of Research Instruments

Validity defines the degree of the findings of a study being interpreted and generalized to a wider population (Cohen *et al.*, 2013). Content validity was done using the result of the pilot study. The research instrument is valid if it captures what it is designed to measure; and the data collected should accurately and truthfully represent the respondent's views (Amin, 2005). Mugenda and Mugenda (2003) state that validity measures the correlation between the data and the variable in question. The views of the supervisors and peer reviewers were used in this research to ascertain the validity of the questions in the questionnaire, and their inputs were valuable in updating the final research instruments.

On the other hand, reliability tests the extent to which a research instrument gives the same results after several trials (Mugenda and Mugenda, 2003). Responses from the pilot study were coded and summarized using Statistical Package for Social Sciences (SPSS), Version 24, and the Cronbach Alpha Index was computed. A reliability index of 0.687 was obtained as an acceptable tool (Appendix 6). Table 3.2 gives a summary scale of rating reliability.

Table 3. 2: Cronbach Alpha test of internal Consistency

Cronbach's Alpha	**Internal consistency**
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good/reliable
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

Source: Modified from Field (2009)

3.9 Data Collection

Data for this study was collected from both primary and secondary sources, and this involved both quantitative and qualitative methodologies. The study employed a combination of data collection methods, namely questionnaires, key informant interviews, focus group~~s~~ discussions (FGDs), direct observation, Satellite images, community mental mapping, and analysis of other relevant topographical maps and publications. The multiple method approach ensured data corroboration and verification.

3.9.1 Structured Questionnaires

Structured questionnaires were administered to 100 sampled respondents who were the household heads, (Appendix 1). The questionnaire involved both close-ended and open-ended questions. The questionnaire consisted of five sections; section A captured the demographic data of the respondents; section B contained questions on housing and sanitation factors; section C considered household socio economic factors; section D considered issues of government and other institutional interventions; whereas section E examined opportunities and barriers for vulnerability reduction. Section A, B and C gave an insight of the socio economic factors at play in determining differential communities' vulnerability to floods responding to the second and third objectives of the study while section D and E were relevant in responding to the fourth objective on flood mitigation measures applicable in Kano plains.

3.9.2 Key Informant Interviews

Key informant interviews were conducted with 10 respondents, using an interview schedule (Appendix 2); and these included officials from relevant government institutions, civil society, and heads of the study sites. County government officials involved were; Environment Director, Disaster Management Officer, Water Resources Management Officer, and NEMA County Director; while World Vision, VIRED and SUSWATCH officers represented the NGOs working in the area. The key informants from the Government institutions, NGOs and civil society organization officials gave information with regards to significant factors at play in determining differential communities' vulnerability to floods and the works and interventions they conduct in Nyando flood plains to mitigate floods while the administrative heads and other key informants in the study area gave their experiences and knowledge about floods in the study area, including information on the most flood hit areas in their areas.

3.9.3 Focus Group Discussions

Focus Group Discussions (FGDs) were used to collect data from a total of 30 sampled participants for the three FGDs sessions that were conducted, one in each study site. Each session had 10 participants comprising five men and five women, also comprising the different age groups and people differently abled, (Appendix 3). FGDs were used for gathering data on the socio-economic determinants for IFM approach and community identified flood risk areas. Data from FGDs was tape-recorded and notes were also taken.

3.9.4 Participatory Community Mapping

Community mental maps were developed by these three groups (FGDs) from each of the study site using a mental mapping guide (Appendix 4). Each group developed one map. The purpose of these maps was to bring out the local knowledge of the community on issues of integrated approach to flood management. The groups were each assigned the responsibility of mapping out flood prone areas within their localities, also identifying higher and safer grounds of refuge. The groups also mapped the land use patterns within the study area. The procedure used in this exercise is explained in Section 3.10.2.6 and Appendix 4.

3.9.5 Direct Observation

Direct observation focused on the effects of floods and the coping strategies adopted by the households (Appendix 5). Direct observation helped to gather information that would not otherwise be obtained using questionnaires and interview schedules. The observations were carried out by conducting transect walks through the study area, and involved taking notes and photographs. These also helped to assess the river course and the areas that get inundated during major floods. The transect walks were undertaken with the guidance of a community person well acquainted with the study area.

3.9.6 Secondary Data

Secondary data included topographical maps, satellite images, rainfall data, flood strategies and reports and other information collected from the internet and through desk and documentary reviews from various sources. These included sources like Kenya National Bureau of Statistics, published and unpublished materials including relevant government publications, and online sources. The data gathered were on socio-economic aspects of Nyando, reports and strategies used for vulnerability reduction as well as areas of flood risks.

3.10 Data Analysis

3.10.1 Quantitative and Qualitative Methods

Quantitative data collected using questionnaires was cleaned, verified, and entered into the SPSS software for analysis. Data was analysed using descriptive statistics, and this was done as per the study objectives, to show relationship between socio-economic factors and their influence on IFM in Nyando. The results were summarized and presented in tables, pie charts, and graphs. In addition, SPSS was used for Chi-square ($\chi 2$) test which is one of the most useful non-parametric tests, also called a distribution free test for testing hypotheses when the variables are nominal (Pearson, 1900). The test was used to show the level of significance of some of the socio economic factors considered for IFM adoption. Where the value of P was less than 5 the null hypothesis for variables under consideration was rejected.

Qualitative data obtained from tape recordings of FGDs were transcribed and thematically analysed through content analysis, using NVivo software. Relevant themes were then generated in relation to the study objectives. Some of the results were presented in narratives. Results from direct observations captured perceptions and views of respondents, as well as structural measures for flood mitigation and effects of floods. Data generated from key informant interviews was also analysed descriptively and through content analysis.

3.10.2 Influence of Geographical Factors

Flood risk boundary maps were generated from the satellite Landsat images of scale 1:10,000 for the years 2011 and 2018 using ArcGIS 10.5 software. Topographical features such as the old and new channel banks, various types of vegetation, soil types, stratification and drainage provided indicators on flood prone areas. The generated maps were finally used, since they provided a clear indication of risk areas as well as fluvial and coastal flooding (SEPA 2011; Quinn *et al*., 2013). These helped to detect differential spatial risks and levels of vulnerability. Data collected using household survey included measurement of elevation (through GPS coordinates). Data on land-use and socio-economic variables were organized and managed in GIS, and later combined with the mental maps inside a PGIS environment for further processing.

3.10.2.1 Stream Network

According to Otiwa and Onywere (2015), the rivers/drainage system in an area affects water output and siltation from the water catchment, and these influence flooding in Kano Plains through the direct hill slope and length of the streams as well as indirectly through their geomorphology. A map of drainage pattern in Kano Plains was generated in ArcGIS 10.5 software using open source data obtained from World Resource Institute website whose shape files for the Kenya sub-county, rivers and lakes were clipped and overlaid.

3.10.2.2 Influence of Slope on Floods

Slope aspect of a catchment affects the surface water drainage direct flow (Cunderlik, 2002). Feloni *et al.* (2020), describes slope as the percentage (%) of the elevation change to the corresponding horizontal displacement. The slope layer in this study was generated in ArcMap from a spatial analysis of the DEM applying slope tool from ArcToolbox (ZWP, 2014). The slope was reclassified into 5 categories on a scale of 1-5 to generate a slope vulnerability map with the value 5 attributed to lower slopes while higher slopes given 1. 5 was attributed to lower slopes since they have a very high influence on flooding, while higher slopes were allocated lesser value since they have little impact on flooding.

3.10.2.3 Soil Drainage

Soil drainage is used as a flood parameter, as it affects aquifer recharge, surface water flow, soil erosion, plant water availability and irrigation management (Chukwudi *et al.*, 2018). The soil drainage parameter influence on floods was generated from the soil drainage map of the study area. A reclassification was therefore done for the generated soil map, into which soils were categorized into 5 classes ranging from 1 to 5, with 1 having the least/lowest influence on flooding, while 5 having the highest influence.

3.10.2.4 Influence of Land use on Floods

A land use map was developed from Landsat 8 of 10/05/2017 downloaded from United States Geological survey to establish the relationship between effects of land use and flooding. The land use map was generated from image classification of the Landsat image.

Assessment of the effects of land use was done through weight calculation. The land use classes were then reclassified with values from 1-5 indicating the influence of each class on flooding. The value factors were assigned 1 for least likely and 5 for most likely to cause floods. The values assigned for land use were based on the most contributing factor to flooding (Harker and Vargas, 1987).

3.10.2.5 Spatial distribution of flood risk and vulnerability in Lower Kano Plains

Weighted analysis involved the combination of data layers of DEM, soil, rivers, land cover, by employing a common measurement scale of values for each rasterized data to produce weighted flood vulnerability ranking. This ranking was used as a corroborative dataset to the developed maps. Weighting was applied using the level of influence of the factors such as, rivers (25%), DEM (30%), land cover (20%), and soil data (25%) (Harker, 1987). Values of the given percentages signified the weight of each factor as a contributor to flooding. These percentages, which represented causative agents of flooding in the study area, were calculated using the formula:

$$w = \frac{(cf * rank)}{\varepsilon(cf * rank)} * 100 \qquad \textbf{\textit{(Equation}}\ \textit{2)}$$

where,

w is weight, and cf is contributing factor.

The sum weight was expressed as 100% using a linear weighted combination (Chukwudi *et al.*, 2018).

Vulnerability Variable = 0.25 River +0.3 Slope +0.25 Soil +0.2 Land use (***Equation 3***)

The Vulnerability variable is the weighed output obtained from the percentages of each variable influence on flooding. The two equations were applied subsequently in the GIS analysis software as algorithms.

The combined datasets formed an integrated analysis, and the weighted output produced a map of two categories namely, areas flooded and areas not flooded; and these categories were based on the calculated output from the four layers and their percentage influence (Otiwa and Onywere 2015). Andi *et al*. (2017) explain that experts use their experimental judgment when assigning these weights through an Analytical Hierarchy Process (AHP), where complex problems with many parameters, whose level of dominance or influence is different, of interrelated objectives are solved. The flood vulnerability map for this study was classified into four categories of floods, namely Very severe, Severe, Moderate, and Low.

3.10.2.6 Digitized Mental Map of Lower Kano Plains

Participatory GIS approach was employed to gather and integrate the local community's knowledge with technical knowledge regarding spatial depiction of areas highly affected by floods. After orienting the participants and identifying the exact location using a topographical map of the study area, the mapping process started by the participants placing a tracing paper on the area's topographical map, and drawing on the tracing paper the boundaries of the areas affected by floods, according to them (Weiner and Harris, 2003). They then, identified each area according to the flood intensity (Very severe, Severe, Moderate and Low) as well as spatial-based socio-economic activities, which were also labeled appropriately, even on the final digital mental map.

In addition, some key landmarks on the topographical map, with known geographical coordinate references were also captured in order to serve as control points that were later used as reference points to transfer the generated information to a GIS environment. This was done through the digitizing process, to form the final soft copy of the mental maps.

According to Rambaldi (2006), this is normally done to better visualize the spatial extents of the mental maps, as was the case in the respective mental flood maps in the study area, and their proximity to rivers and streams. The mental maps generated by the communities used relevant topographical maps and Landsat images as a base.

The topographical maps and Landsat images for the years 2011 and 2018 were at a scale of 1:10,000, being the years with the most destructive flood events experienced in the recent past (Okayo *et al.*, 2015; CHIRPS, 2019). The topographical maps of the study area were obtained from the Regional Center for Surveying and Mapping (WRI 2019). These maps were digitized, geo-referenced, and integrated with other datasets of administrative boundaries, drainage systems and water bodies, roads, which were downloaded from World Resource Institute website, to clearly map out the affected areas in ArcGIS. Digital elevation data for the year 2019 was downloaded from United States Geological Surveys website (USGS 2019). A Landsat 8 image was also downloaded from USGS website for land use land cover analysis. Figure 3.2 gives information on rainfall for Nyando basin between the years 2010 to 2018 being the period under consideration.

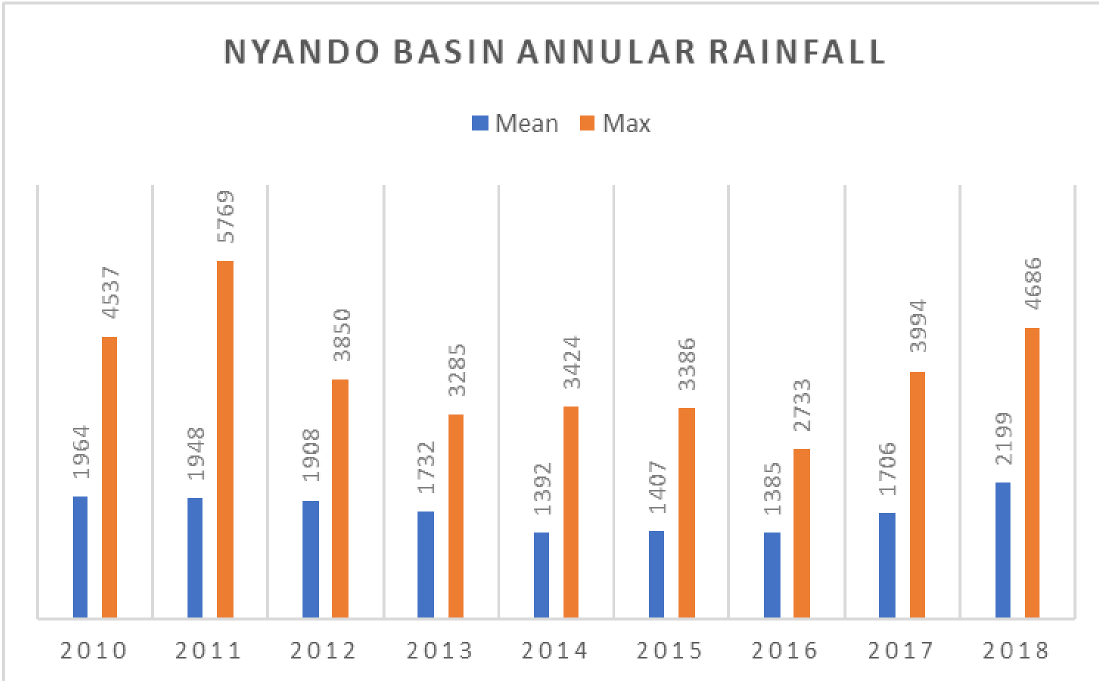

Figure 3. 2: Annual Rainfall Data for Nyando Basin Period 2010-2018 (Source: CHRIRPS, 2019)

Table 3.3 gives a summary of data collection and analysis.

Table 3. 3: Summary of Data Collection and Analysis

S/N	Objective	Data collection methods	Data analysis methods
1	To establish flood risk areas of lower Kano Plains in Nyando sub-catchment	Landsat images of 2011 and 2018, obtained from the Regional Center for Surveying and Mapping FGDs Mental maps Desk reviews	ArcGIS, digital elevation models (DEMs) of Nyando River/stream network, especially at the mouth near Lake Victoria. Content analysis using NVivo software
2	To assess the socio-economic determinants of community vulnerability to floods in the flood risk areas of Kano plains.	Questionnaires Desk documentary reviews FGDs Key Informants Interviews Direct observation, through Transect walks	Descriptive statistics using SPSS and Excel spread sheets Chi Square Test Content analysis using NVivo software
3	To determine the effects and vulnerability of flood events in flood risk areas in Kano Plains.	Questionnaires Desk documentary reviews FGDs Key Informants Interviews Direct observation, through Transect walks	Descriptive statistics using SPSS and Excel spread sheets Content analysis using NVivo software Development of digital mental maps in GIS
4	To evaluate the effectiveness of existing mitigation measures for flood management in lower Kano plains.	Questionnaires FGDs Desk documentary reviews Direct observation, through Transect walks Key Informants Interviews	Descriptive statistics using SPSS and Excel spread sheets Content analysis using NVivo software

3.11 Data Management and Ethical Considerations

Both qualitative and quantitative data collected for the study were verified and analyzed thematically, as per the objectives of the study. The data collected was on the socio economic factors at play in integrated floods management and these were collected through the survey at the household level.

An introductory letter (Appendix 7) was obtained from Kenyatta University, through the Department of Geography; and a permit to carry out the research (Appendix 8) was also obtained from the National Commission for Science and Technology (NACOSTI). All the data in the study was collected with approval from the relevant authorities and with the knowledge of the administrative heads. Data collected was also handled with utmost confidentiality, and where the respondents wished to remain anonymous, it was done. Ethical issues such as avoiding deception, betrayal of respondents' privacy were strictly adhered to in this study (Cohen *et al*., 2013). Consent of the participants to take part in the research was also obtained before being engaged in it.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents, first and foremost, the demographic characteristics of the sampled respondents. In addition, the chapter presents and discusses the results based on the objectives of the study. The results presented here include findings related to flood risk areas of the study area; the socio-economic determinants of community vulnerability to floods; the effects and vulnerability of flood events in flood risk areas; and the effectiveness of existing mitigation measures for flood management.

4.2 Questionnaire Return Rate

Even though 100 questionnaires were distributed to the sampled respondents, only 91 were completed and returned; thus giving a return rate of 91% (Table 4.1). Mugenda and Mugenda (2003) say that a return rate of 60% is good and 70% and above is excellent. Therefore, the results presented in this chapter were based on this value.

Table 4. 1: Questionnaire Return Rate

Sub Location	Target Population (N)	Sample size (n)	Returned Questionnaires	Return Rate (%)
Miwani	90,873	30	27	90.00
Nyando	161,508	53	49	92.45
Lower Nyakach	53,418	17	15	88.24
Total/Average	**305,799**	**100**	**91**	**90.23**

Source: Author (2019)

The key informant interviews return rate was 100% since all the 10 sampled key informants were interviewed. The response was representative to make informed conclusions for the study.

4.3 Demographic Characteristics of the Respondents

This section considered the gender, age, and level of education, of the respondents.

4.3.1 Gender of the Respondents

Gender of the respondents in this research was as shown in Figure 4.1;

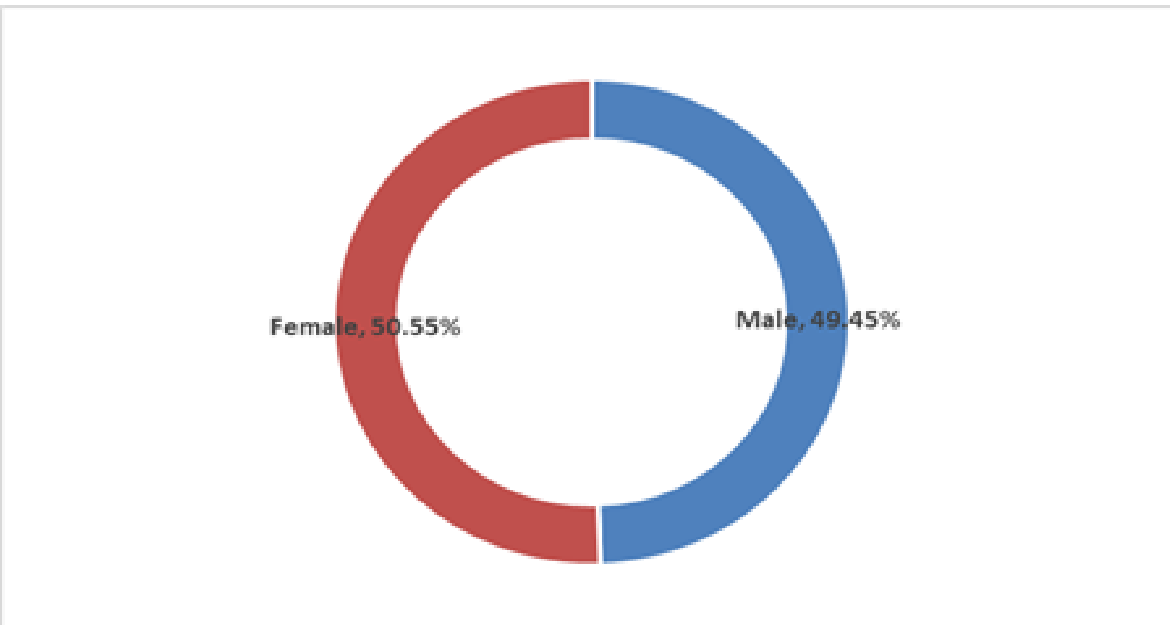

Figure 4. 1: Gender of the Respondents (Source: Author, 2019)

The study comprised 50.55% females and 49.55% males. From this finding, it shows that the information collected was representative, with a ratio of 1:1 since both had equal chances of airing their views regarding the topic of this study.

4.3.2 Age of the Respondents

This study found the ages of the respondents as summarized in Figure 4.2;

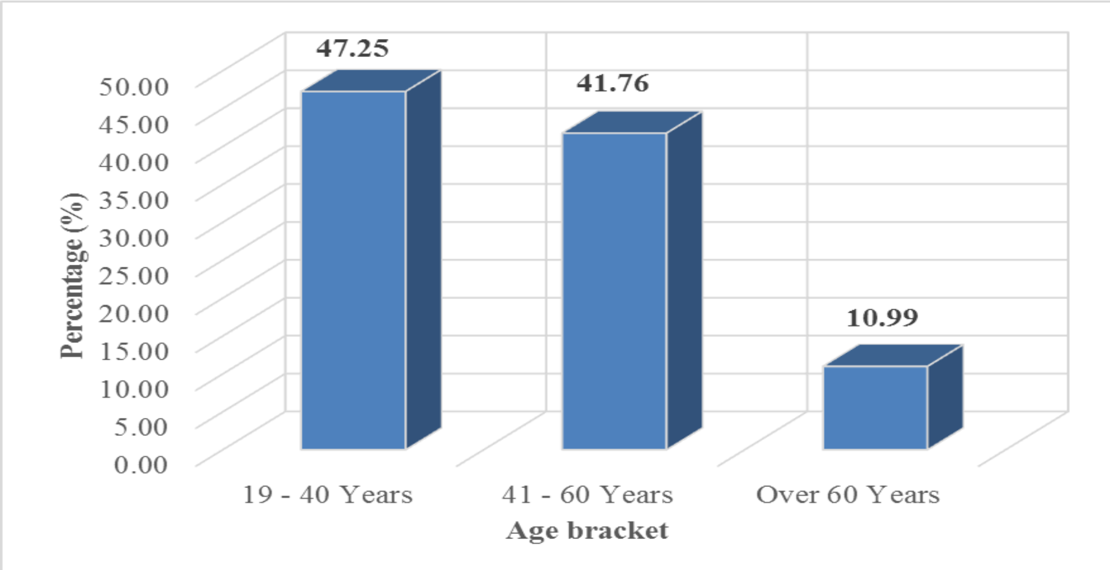

Figure 4. 2: Age of the Respondents (Source: Author, 2019)

Majority (47.25%) of the respondents were aged from 19– 40 years old, followed closely by 40 – 60 years old at 41.76%, while those over 60 years old were 10.99%. These findings show that most of the respondents interviewed were old enough to have some information on the history of flooding in Kano Plains.

4.3.4 Level of Education of the Respondents

The study established that the level of education attained by the respondents were as summarized in Table 4.2. The education level of the respondents is pertinent in the study since it showed various community members' knowledge on the potential flood hazards and the level of awareness on their vulnerability to flooding in Kano plain. It also helped in determining the push and pull factors for residing in flood plain and their knowledge in the coping strategies to the flooding.

Table 4. 2: Level of Education of the Respondents

Education Level	**Frequency (n=91)**	**Percentage (%)**	**Frequency affected (n=89)**	**% Affected**
Secondary	47	51.65	46	51.69
Primary	37	40.66	37	41.57
Tertiary College/University	6	6.59	5	5.62
No formal Education	1	1.10	1	1.12
Total	**91**	**100.00**	**89**	**100.00**

Source: Author, 2019

4.4 Geographical and Land-use Determinants of Floods in Flood Risk Areas of Kano Plains

Apart from analyzing the socio-economic determinants for IFM, this study also examined the influence of geographical and land use determinants of floods in the study area. These were established using mainly data from satellite images, topographical maps, and community mental maps. Therefore, the results presented here were based on an analysis of the rivers/streams network, slope, soil, and land use. An integrated flood vulnerability map was also generated by overlaying the digitized community mental maps with a flood vulnerability map of the area.

4.4.1 Influence of Drainage Pattern on Floods

As illustrated in Figure 4.3, floods are more prone to areas with dense network of streams at the river mouth, and Nyando and Nyakach were found to be highly affected by floods.

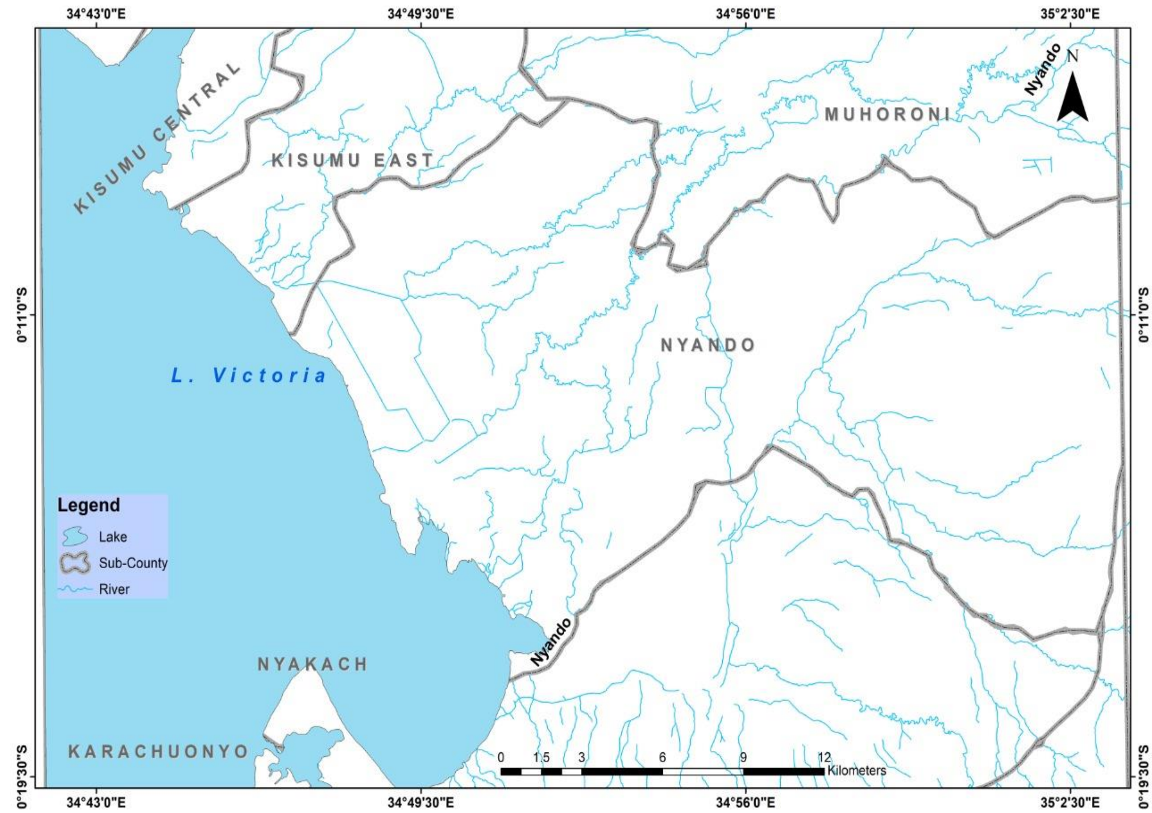

Figure 4. 3: Drainage Pattern in Kano Plains (Source: Generated from RCMRD data using ArcMap 10.7 (10.5.2019)

Regions with multiple drainage networks were found to have high incidences of flooding. South western part of the study area registered low drainage influence hence had low incidences. The results here were similar to a study by Otiwa and Onywere (2015) who found drainage network to be a significant factor influencing flooding.

4.4.2 Influence of Slope on Floods

The slopes in the study area ranges from a level of 0 degree on the shores of Lake Victoria, to a high of 34.86 degrees in Nandi hills towards the southeast. Areas with a low slope experience more floods than high lying areas. From Figure 4.4 and Table 4.3, the influence of slope on flooding ranges from Very High (Category 5), at the shores of Lake

Victoria to the southwestern side of Kano Plains, to Very Low (Category 1), which is the catchment of Nyando River, located in the northeastern part of Nandi Hills.

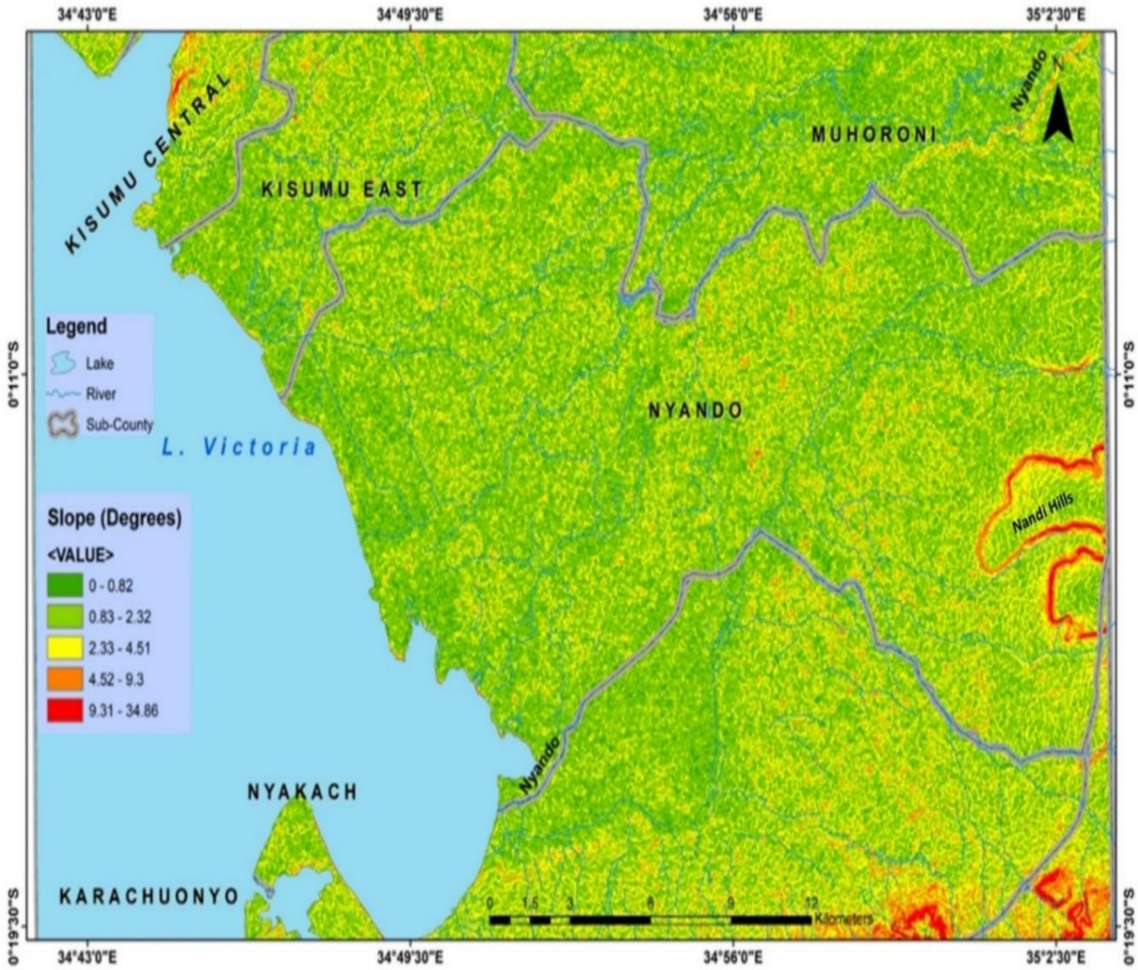

Figure 4. 4: Influence of Slope on Floods within Kano Plains (Source: Generated from DEM dated 06/09/2017)

These findings correspond with those of Chukwudi *et al.,* (2018), who found that low lying areas were most susceptible to floods as most people residing there relied on the rivers and streams as their main sources of water, thus exposing them to the flood risks.

Table 4. 3: Relationship between Slope and Flood Risk

Category of Slope	***Level of Flooding***	***Slope (Degrees)***
5	Very High	0 - 0.82
4	High	0.83 - 2.32
3	Medium	2.33 - 4.51
2	Low	4.52 - 9.3
1	Very Low	9.31 – 34.86

Source: Author, May 2019

4.4.3 Influence of Soil Types on Floods

As shown in Figure 8, Kisumu Central and the areas surrounding Lake Victoria have poorly drained clay soil. Areas with very poorly drained soils, imperfectly drained soils and poorly drained soils were more susceptible to flooding unlike areas with well drained soils. Soil drainage also affects the water infiltration rates, whilst well drained soils have higher infiltration compared to poorly drained soils (Otiwa and Onywere 2015). During rainy seasons, flooding occurs severely in the poorly drained soils compared to well drained soils.

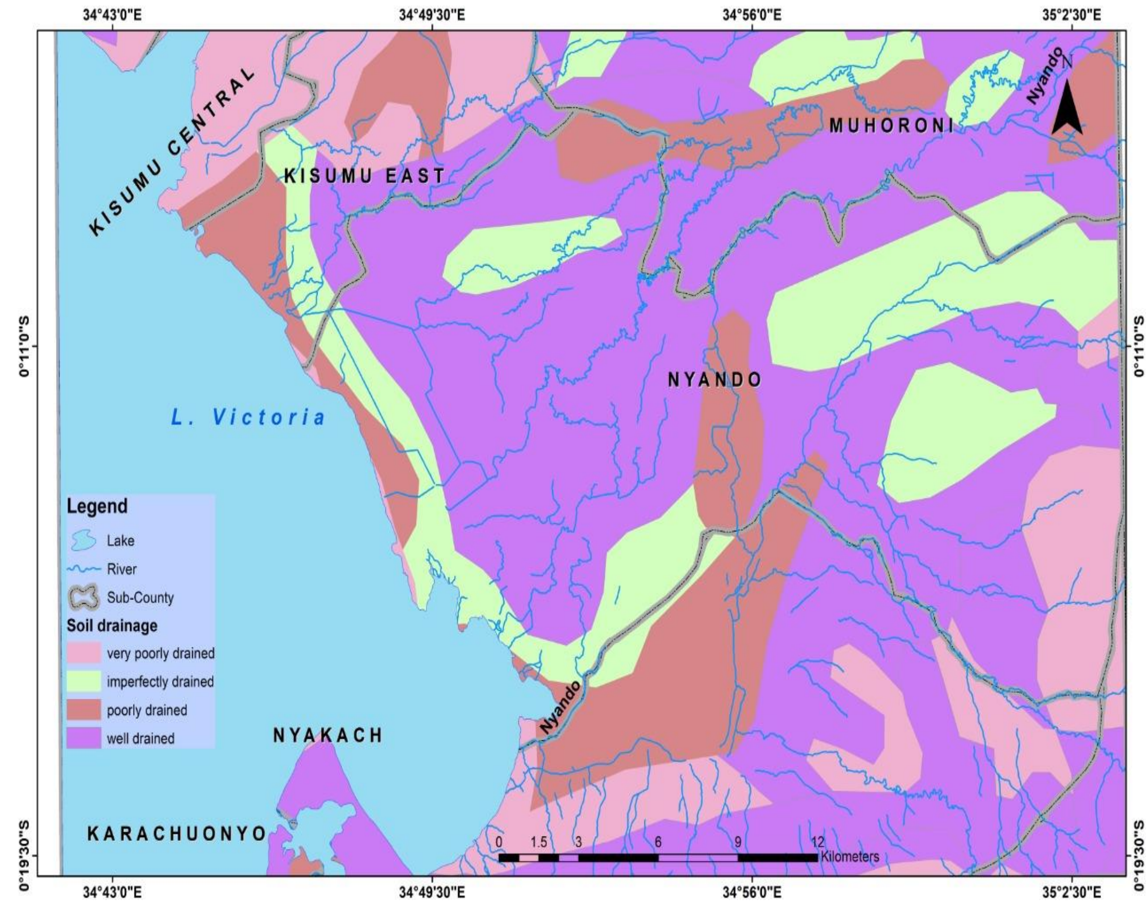

Figure 4. 5: Soil Drainage of Kano Plains (Source: Generated from Kenya National Soil survey data using ArcMap 10.7 (2019)

The poorly drained soils found along the shore of Lake Victoria (Figure 4.5) were found to be highly vulnerable to flooding hence the value 5 (Figure 4.6). The areas marked with the values 3 and 1 indicate low vulnerability to flooding. This finding agrees with that by Andi *et al*. (2017), who note that during the rainy season, the infiltration process decreases overtime in the poorly drained soils due to water logging as a result of a high rainfall intensity, and this condition leads to flooding.

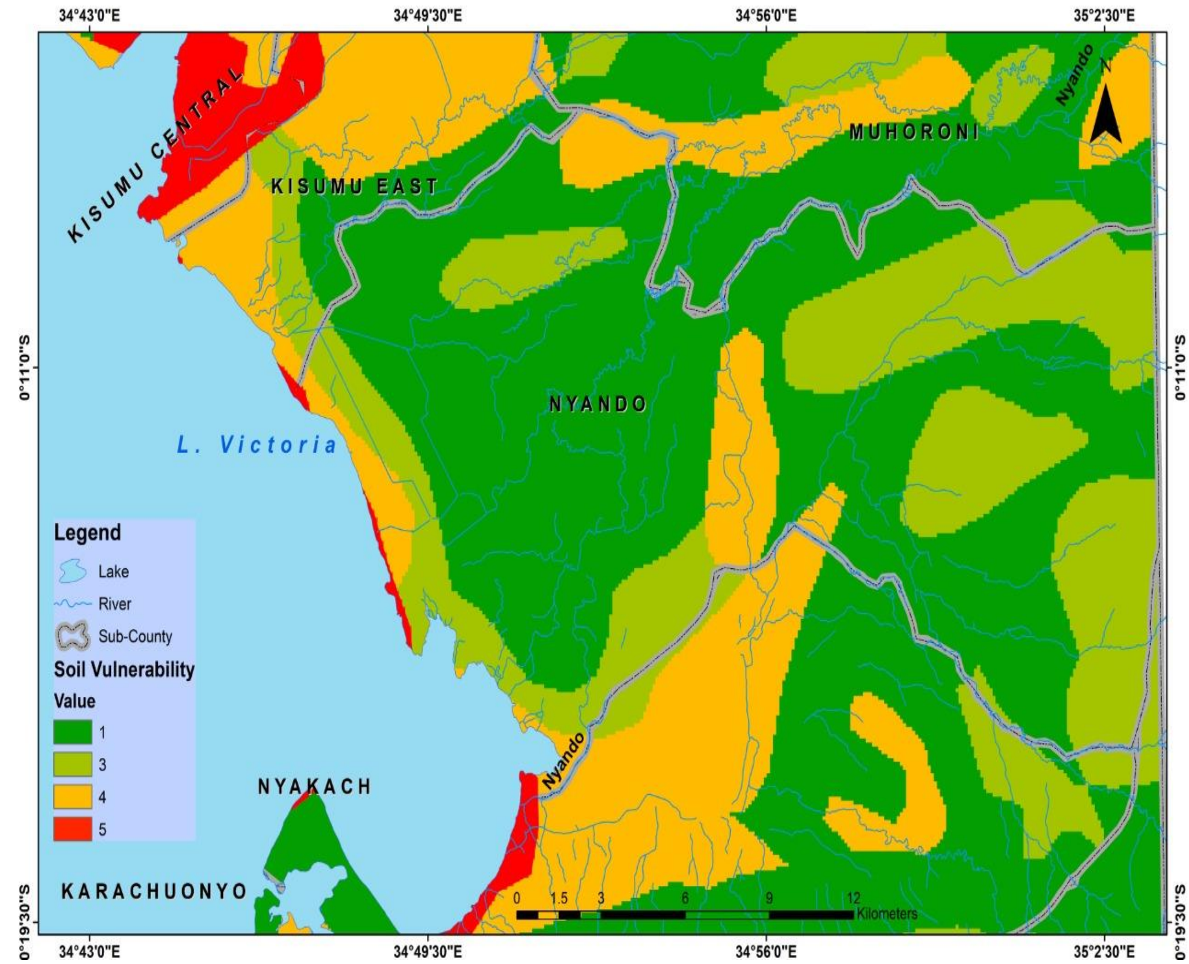

Figure 4. 6: Soil Vulnerability Map for Kano Plains (Source: Generated from Kenya National Soil survey data using ArcMap 10.7 (2019).

4.4.4 Influence of Land Use Types on Floods

The study identified seven land use types as follows: dense agriculture, sparse agriculture, bushland, plantation, swamp, town, and water body, as shown in Figure 4.7.

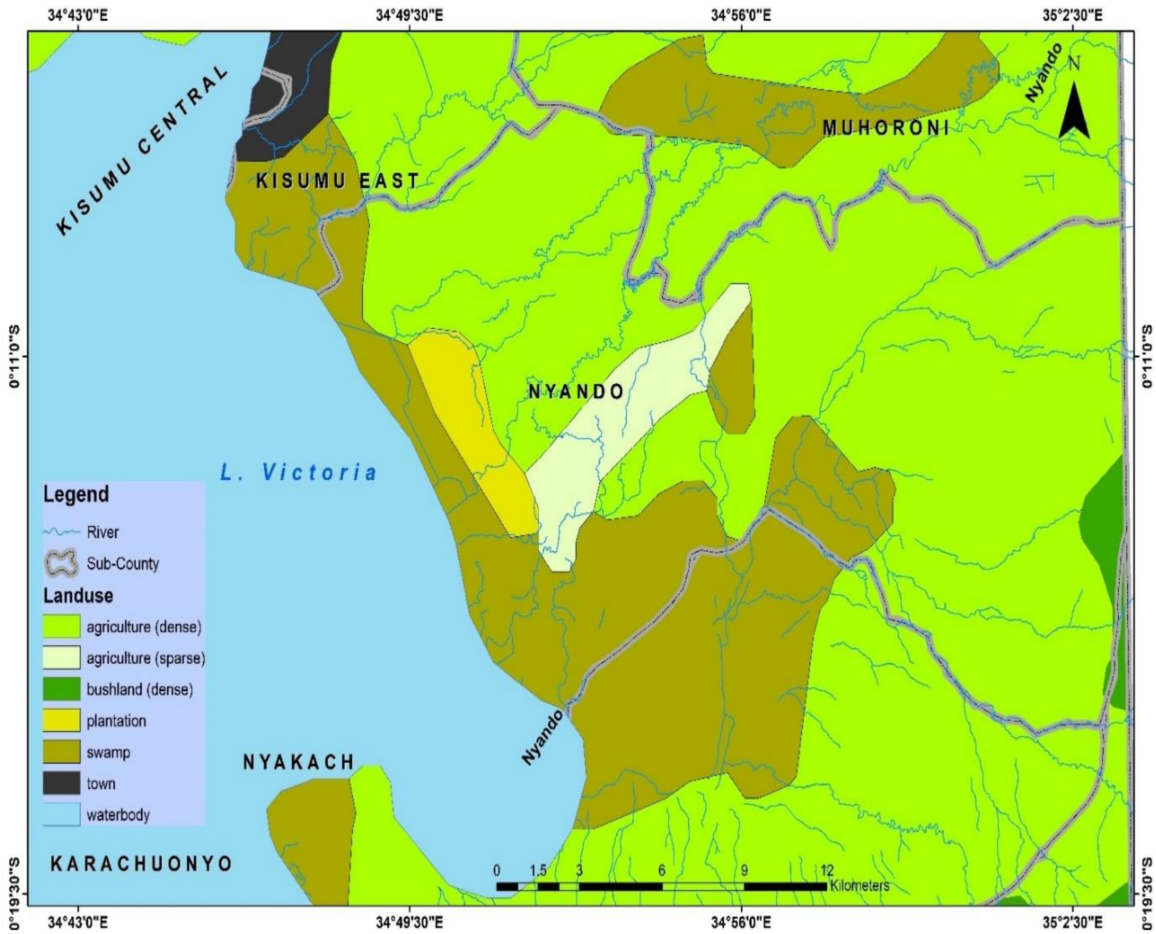

Figure 4. 7: Land use Map for Kano Plains (Source: Generated from Landsat 8 of 10/05/2017 using ArcMap 10.7 (2019)

The study established that areas with forests or vegetation cover had high infiltration rates and consequently had low flood susceptibility, hence assigned value 2 (Table 4.4). These included agriculture and Bush land which were similar to findings by (Chukwudi *et al.* 2018). Plantations and swamps were assigned value 3 and 4 respectively and they signified areas with moderate flood susceptibility. Although surface runoff is generally considered high in built-up areas because of impervious surfaces, this was not the most likely factor to contribute to floods in this study, thus the town was-assigned value 1. This is because only a small area of Kano plains consists of towns except, (Miwani, Ahero, Katito and Pap Onditi) with buildings and pavements that can cause significant runoff which could cause floods. The findings here contradict that of Andi *et al*. (2017) conducted in Okazaki city which basically had a larger built up area.

Table 4. 4: Classified Values for Land use influence on Flood Vulnerability in Kano Plains

Contributing Index (Land use)	**Value of Contributing Index**
Town	1
Water body	5
Plantation	3
Swamp	4
Bush land dense)	2
Agriculture (sparse)	2
Agriculture (dense)	2

Source: Adopted from Otiwa and Onywere (2015)

Figure 4.8 shows the land use classification based on the value of the contributing index to flooding within the study area. This classification indicates areas of different levels of vulnerability to flooding.

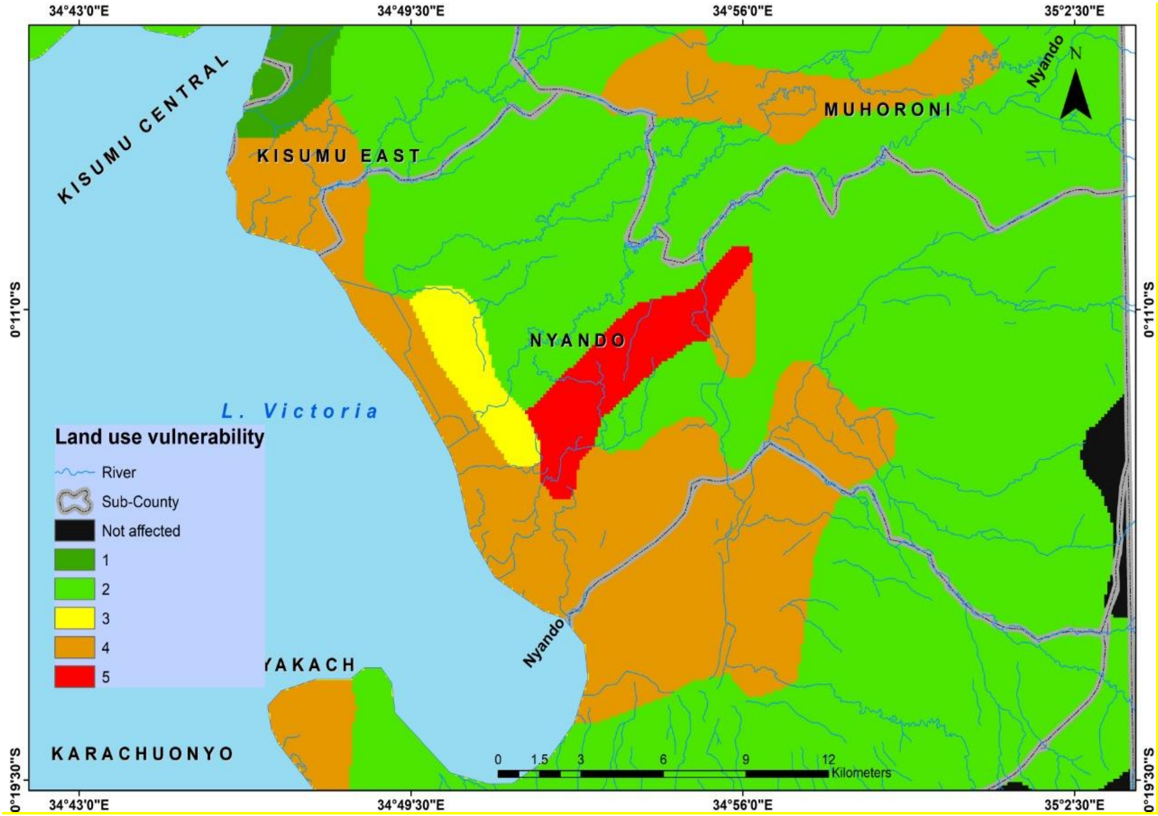

Figure 4. 8: Land use Influence on Flooding in Kano Plains (Source: Generated from Landsat 8 image of 10/05/2017, USGS)

4.4.5 Spatial Distribution of Flood risk and Vulnerability in Lower Kano Plains

In analyzing the weight of the other determinants, it is evident that slope has the highest weight (Table 4.5). This implies that slope contributes more to flooding than the other variables. Slope influences the flow direction; it also has dominant influence on drainage flow, duration of water infiltration and duration of flow.

Table 4. 5: Weighted Flood Vulnerability Ranking

Variables	Relative Weight (%)	Reclassified Factors	Flood Vulnerability Index
Slope	30	0 – 0.82	5
		0.83 – 2.32	4
		2.33 – 4.51	3
		4.52 – 9.3	2
		9.31 – 34.86	1
Soil	25	Well drained	1
		Moderately drained	3
		Poorly drained	4
		Very poorly drained	5
Land use	20	Agriculture (dense)	2
		Agriculture (sparse)	2
		Bushland	2
		Plantation	3
		Swamp	4
		Town	1
		Waterbody	5
Rivers	25	Very High	5
		High	4
		Medium	3
		Low	2
		Very Low	1

Source: Adopted from Andi *et al.* (2017)

The output from the multi-criteria weighted overlay analysis was a flood vulnerability and prediction map (Figure 4.9).

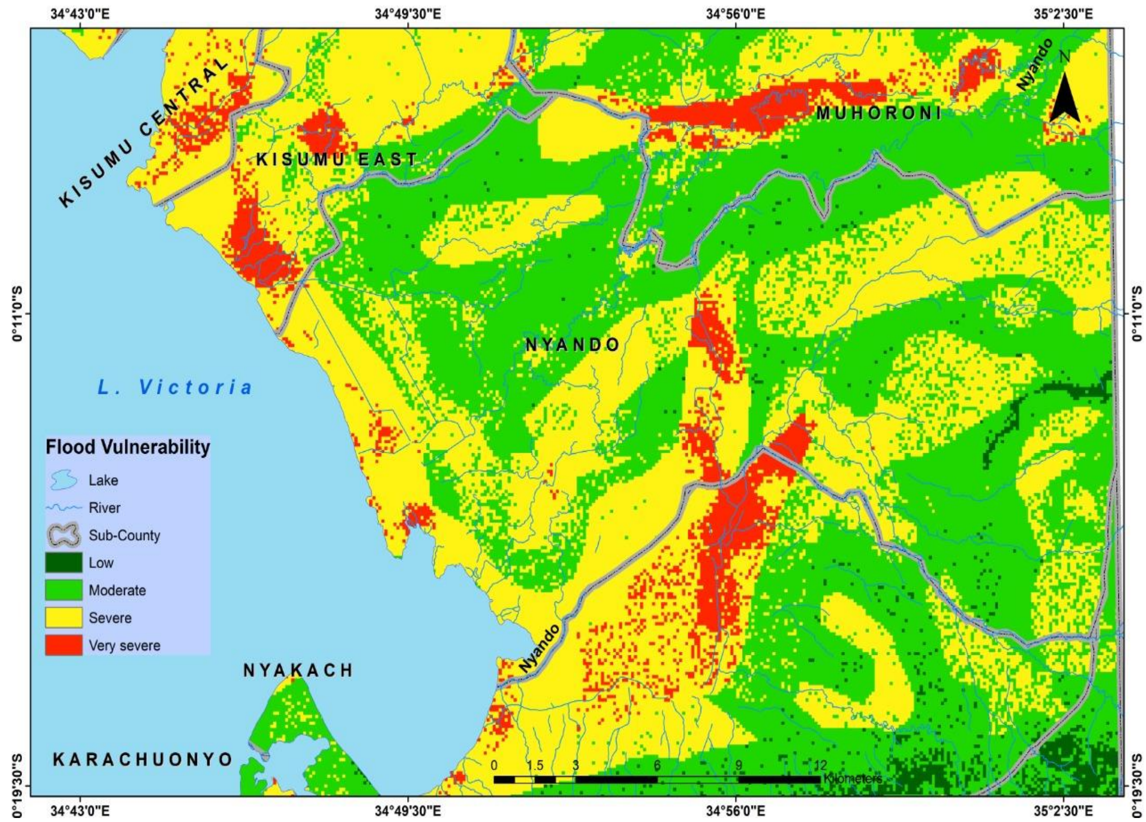

Figure 4. 9: Flood Vulnerability and Prediction Map for Lower Kano Plains (Source: Generated from ArcMap 10.7)

The results indicate that 26.36% of the study area was categorized as Very severe flood vulnerability, and this was largely located on the lowlands around Lake Victoria, as well as the northern and southern part of the map. These areas were close to the plantations and where the main tributaries of rivers Nyando and Awach, were concentrated. The area around Lake Victoria (Figure 4.9) is classified as Very severe as water would naturally flow in the path with least resistance and settle at the lowest point on land or depression unlike the highland to the southern part of the map that registered a low flood vulnerability index, attributed to the steep slopes. Ahero town as seen from the land use map is prone to flooding due to very poorly drained soils. The findings here agree with the findings of

Feloni *et al*. (2020) who used a multi-criteria approach to flood vulnerability assessment that yielded the same results.

4.4.6 Crude Community Mental Map

The community came up with a mental map of the study area where areas moderately, severely and very severely hit by floods were clearly mapped out as depicted in Figure 4.10.

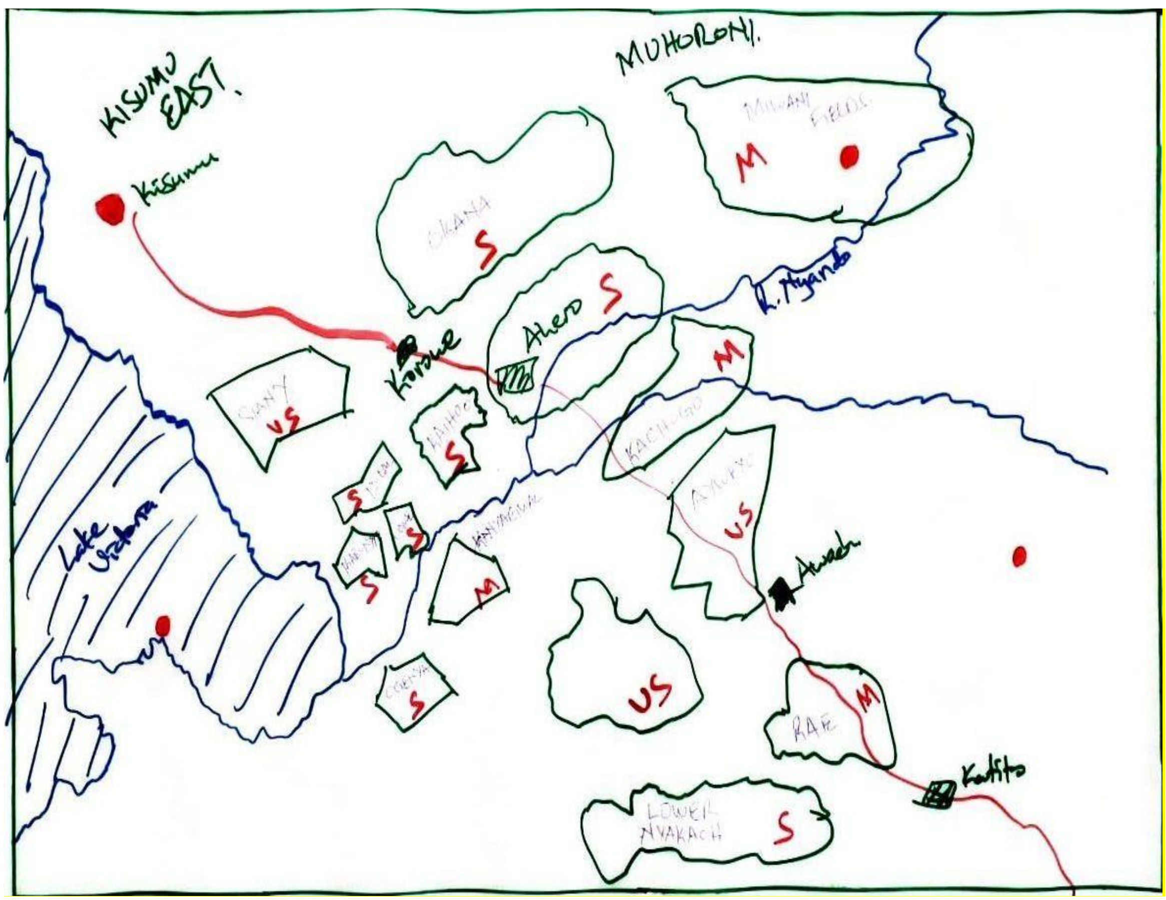

Figure 4. 10: Community Mental Map (Source; Kano Plains Community FGDs May 2019)

4.4.7 Digitized Mental Map of Lower Kano Plains

Figure 4.11 presents a combined mental map of flood risk areas of Kano Plains in the three study sites as depicted by the sampled community respondents.

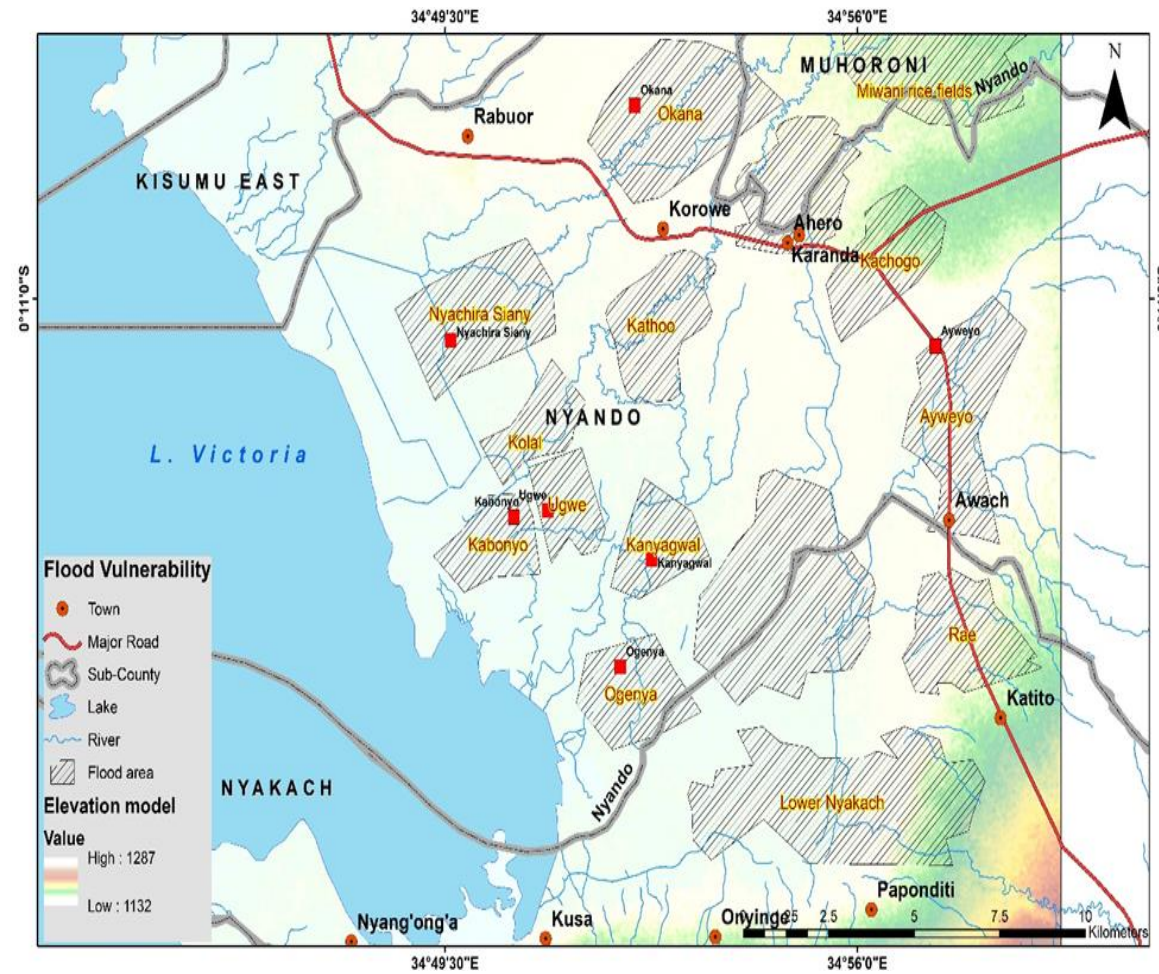

Figure 4. 11: Digital Mental Map of Kano Plains (Source: Developed by Researcher from Participatory Mental Maps using ArcMap 10.7 (28/05/2019).

The respondents reported that the severity of the floods was different with respect to each of the three study sites. One participant from the FGD in Miwani Sub Location stated:

> *"The main reason why areas here are differently affected by floods is because of the spatial (geographical) and socio-economic differences. For instance, in Nyando* sub-County*, due to the geographical differences such as flat terrain, some areas consist of wetlands, marshy and boggy environments that allow pools of water to collect*". *(FGD 14th May 2019)*

Members also explained that due to their low income levels, and the fact that most of them lived in inherited land, they had no means of getting alternative areas of settlement and that is why they had been forced to live in such ecologically fragile environments in the plains. In Lower Nyakach Sub Location, the respondents explained that the silted water ways, constructions in the river channels, and the near zero slope, contributed greatly to floods in the area. The many wetlands located within the area were also cited as major causes of floods since they tend to retain the water and not allow it to run off towards the lake. The results of this study agrees with that by Kienberger (2014) who found that overlaying community mental maps on DEM helped in understanding the influence of slope and topography on flood hazard zones.

4.4.8 Integrated Flood Vulnerability Map for Lower Kano Plains

An overlay of the flood vulnerability map was made with the mental map for Lower Kano Plains. The overlay was made of the “local knowledge” and “expert knowledge” to assess the flood vulnerability based on spatial position. Figure 4.12 indicate the delineated local and expert flood prone areas in Lower Kano Plains which are mainly located in Kanyagwal, Rae, Kochogo, Ogenya, Kabonyo, Nyachira Siany and Lower Nyakach. Miwani area at the northern section of the map was also found to be highly flood vulnerable. They lie within the 26.36% of the study area categorized as Very severe flood vulnerability.

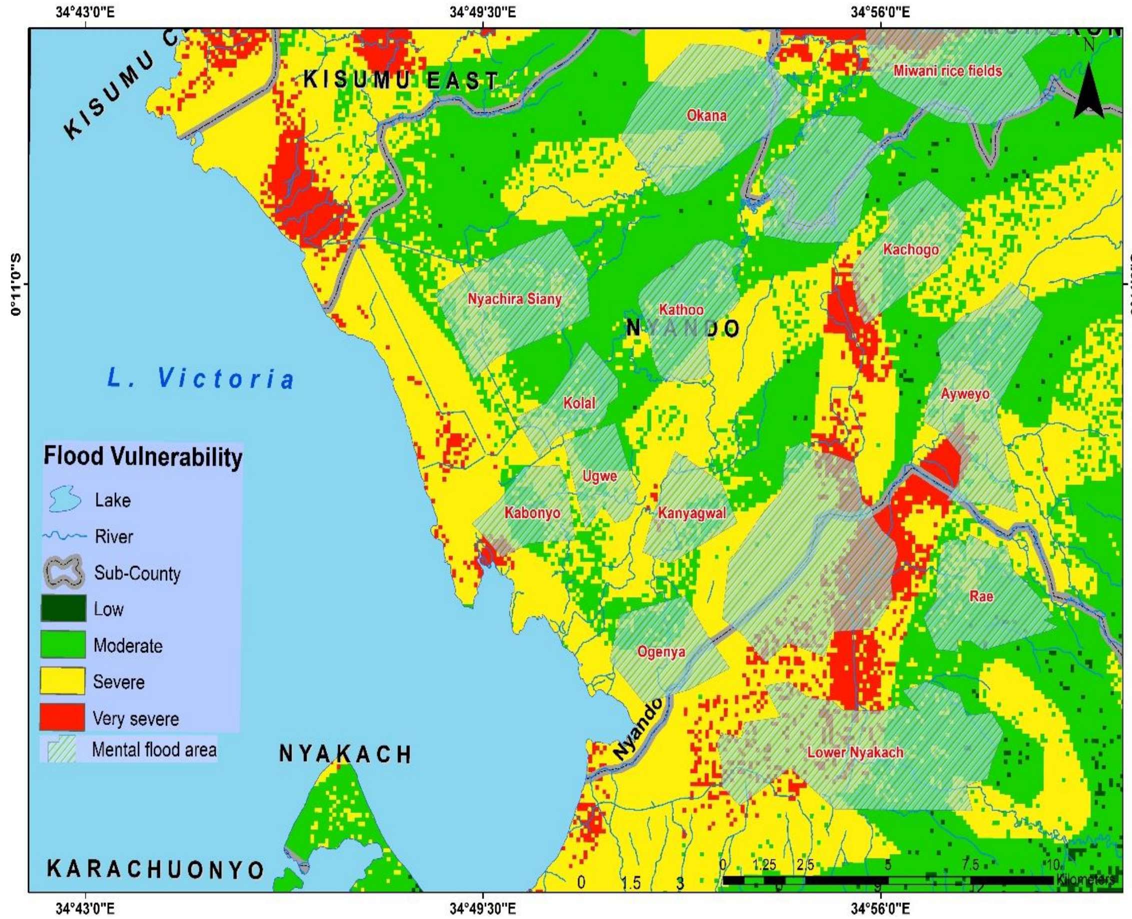

Figure 4. 12: Integrated Flood Vulnerability Map for Lower Kano Plains (Source: Generated using ArcMap 10.7, 2019)

From Figure 4.12, it is clear that most of the community identified areas coincided with the results from traditional GIS flood risk mapping. These results agre with those by Rambaldi (2006).

4.5 Socio-economic Determinants of Community Vulnerability to Floods in the Flood Risk areas of Kano plains

In this section, we present results of the socio-economic determinants of community vulnerability to floods in the flood risk areas of the study area. Issues that were considered under this section included; Gender, Education, Marital status of the respondents, Size of household and dependency ratio, Period of respondents' stay, Level of income, the influence of households' proximity to River Nyando, the vulnerability of types of housing to flooding, and livelihoods. These issues were considered to be some of the factors important for vulnerability assessment.

4.5.1 Gender

It has been widely acknowledged that men and women are affected differently by disasters due to the differences that exist in their social relations. From the study, (Table 4.6), it was established that the contribution of gender to differential vulnerability was small, with 50.56% of respondents agreeing that women were most affected by floods than men while 46.06% saying men were the most affected gender. The percentage variance being less than 5% indicated that both men and women were affected by floods in similar ways, the reason for this being gender roles in the modern days cross-cut and therefore both gender were likely to be affected equally, contrary to the findings of Odeyemi and Peter (2018).

Table 4. 6: Gender affected by floods

Gender affected by floods	Frequency (n=89)	Percentage (%)
Women	45	50.56
Men	41	46.06
Neutral	3	3.37
Total	**89**	**100.00**

4.5.2 Education

98.90% of the respondents had formal education (Table 4.3), indicating a high level of formal education among the residents in the study area. However, of these 98.90%, 89 respondents, were still affected by floods, Table 4.3. The findings here contradicting those of Odeyemi and Peter (2018) that acknowledged education to be an indicator of cultural capital that gives a prediction of potential vulnerability to disasters, thereby increasing uptake of precaution.

4.5.3 Marital Status of the Respondents

Concerning marital status of the respondents, the results given in Table 4.7 were found.

Table 4. 7: Marital Status of the Respondents

Marital status	Frequency (n=91)	Percentage (%)	Frequency (n=89)	% Affected by floods
Married	70	76.92	68	76.40
Widowed	15	16.48	15	16.85
Single	4	4.40	4	4.49
Divorced	2	2.20	2	2.25
Total	**91**	**100.00**	**89**	**99.99**

Source: Author, 2019

Table 4.7 indicates that a (81.32%) of the respondents were married, 12.09%–were widowed, while 4.40% were single, and 2.20% were divorced. Nethengwe (2007) acknowledges family and social resources as valuable indicators of flood vulnerability. Social networks can provide avenues of support and assistance during disasters. The tendency of households most affected by floods lying with the widowed, single and divorced (Table 4.7) the findings correlating with Yamano and Jayne (2002) research that found that households headed by 2 people are better placed to cope with floods than those headed by single heads.

4.5.4 Size of Household and Dependancy Ratio

It was crucial to know the households' size; since this influenced their effort to generate income which dictated their economic power. Results are captured in Figure 4.13.

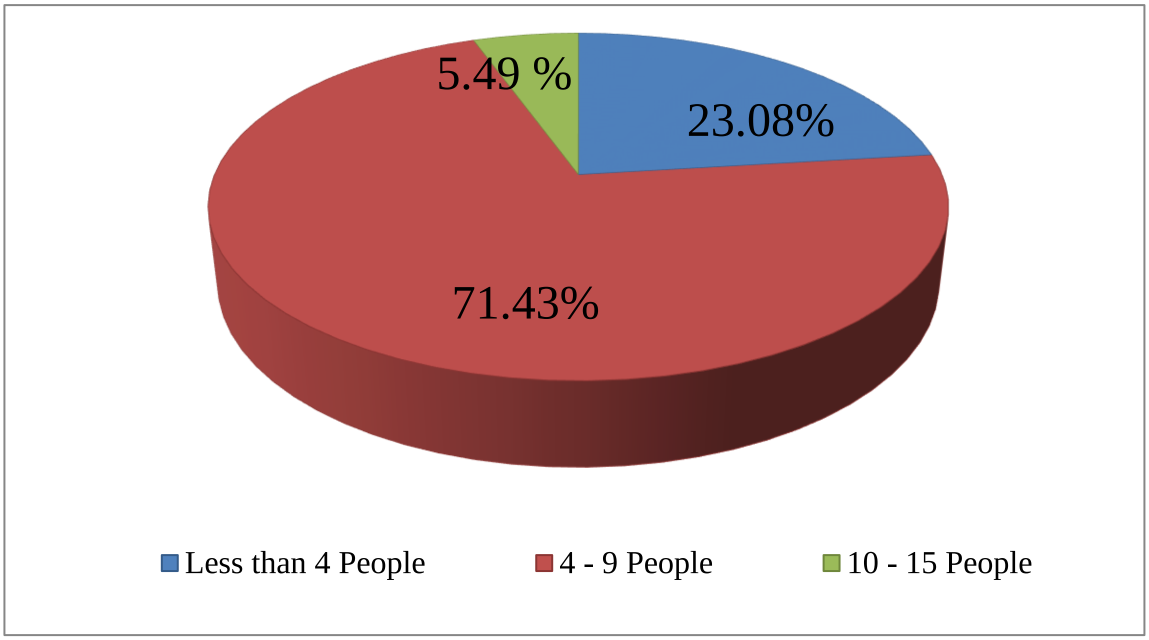

Figure 4. 13 Size of Household (Source: Author, 2019)

Figure 4.13 revealed that 23.08%, 71.43% and 5.49% of the respondent were members of household size of less than 4 people, 4 - 9 people, and 10 - 15 people respectively. These findings gave insight on the possible vulnerability of the households that included the number of children to take care of, and senior citizens in case of any floods events. Similar to the work of Odeyemi and Peter 2018, the findings meant that households in the study area were more vulnerable to floods, due to their large number of dependents.

4.5.5 Period of respondents' stay in Kano Plains

The period of respondents' stay in the study area was as shown in Table 4.8.

Table 4. 8: Period of stay of the Respondents in Kano Plains

Time	Frequency (n=91)	Percentage (%)
1 – 3 Years	2	2.20
4 – 5 Years	44	48.35
More than 5 Years	1	1.10
Resident by Birth	44	48.35
Total	**91**	**100.00**

(Source: Author, 2019)

The study found that 48.35% of the respondents had either resided in Kano Plains for a period of 4 - 5 years or being residents by birth, 2.20% had stayed for 1 - 3 years, and only 1.10% had resided for more than 5 years after relocating to the flood plain. Table 4.8 shows that a majority (48.35%) of the respondents were residents by birth. These findings revealed that most respondents had resided in the study area and therefore must have experienced flooding, and thereby expected to have knowledge on how best to cope with floods. This however was not the case as most residents here still got affected by floods, correlating with the results of a survey carried out on flood victims of the 2002 Melde Flood in Eilenburgh (Kuhlicke, 2006).

4.5.6 Level of income of the Respondents

The level of income of the respondents was as given in Figure 4.4. The level of income was found to be an important factor in preventing or reducing effects of disasters such as floods. People may continue living in disaster prone areas because they may lack the ability to move to safer places. Therefore, understanding the income levels of the respondents was important in understanding the resilience level of the population.

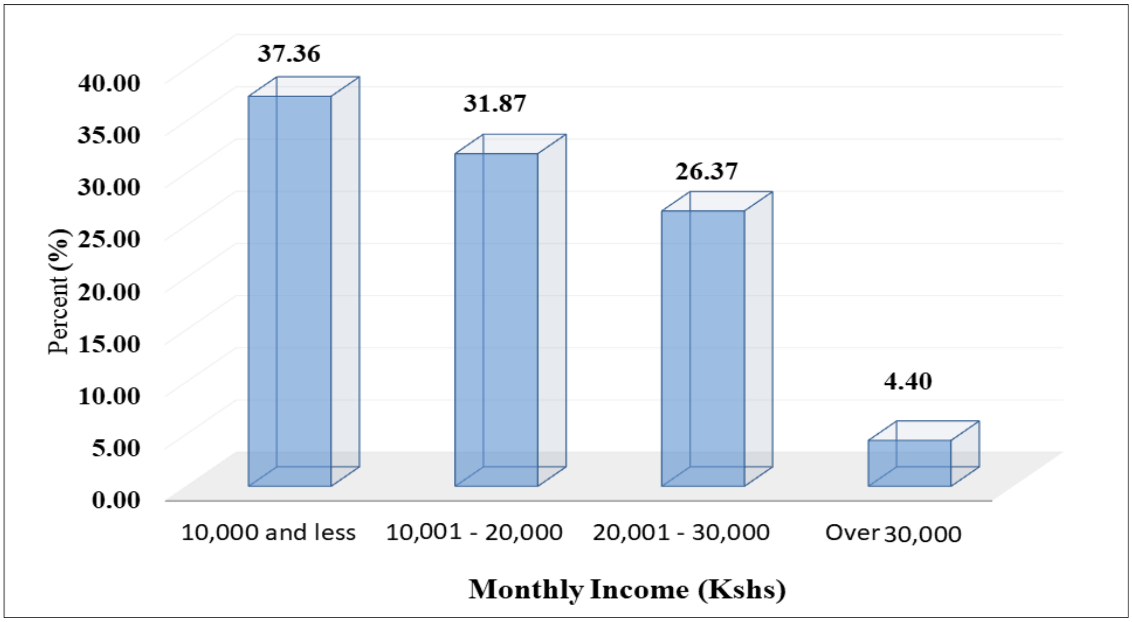

Figure 4. 14: Respondents' Monthly Income (Source: Author, 2019)

Figure 4.14 shows that 37.36% of the respondents earned Kshs. 10,000 and less, followed by 31.87% who earned Kshs. 10,001 - 20,000, while 26.37% earned Kshs. 20,001 - 30,000, and only 4.40% of the households earned above Kshs. 30,000. The findings indicated that a majority (69.23%) living in the Kano flood plain earned a monthly income of less than Ksh. 20,000. This may mean that their level of financial capacity to cope with flood events is low, thus high vulnerability and risk. These findings concur with the study by Raburu and Okeyo-Owuor (2005), who found out that low economic status of the riparian communities had increased their demand for wetland resources, where they overexploited the resources therein including using it for livestock and crop farming, thus exacerbating their vulnerability. SERA Project (2002), similarly found a correlation between household resources and flood vulnerability to be that coping with and recovery from flood impacts demand resources that can cushion the household from negative flood impacts.

4.5.7 Households' proximity to River Nyando

The study sought to determine the households' proximity to River Nyando, as this could result in the severity of effects of floods in the Kano Plains. The distances were obtained from satellite images of scale 1:10,000 of the study area.

4.5.7.1 Households' proximity to River Nyando descriptive statistics

A two-way contingency table (Table 4.9) was conducted to evaluate whether households' proximity was associated with livelihoods affected by floods in Kano plain. The proximity to river Nyando had six levels (Less than 100 Meters, 101 - 300 Meters, 301 - 500 Meters, 501 - 700 Meters, 701 - 900 Meters and more than 900 Meters) whereas livelihoods affected by floods had two levels (yes and no).

Table 4. 9: Households' proximity to River Nyando vs Livelihoods affected by Floods

			Livelihood affected by floods		
			Yes	No	Total
Respondent distance from the River	Less than 100 Meters	Count	7	0	7
		Expected Count	6.8	.2	7.0
		% within Respondent distance to the River	100.0%	0.0%	100.0%
	101 - 300 Meters	Count	28	2	30
		Expected Count	29.3	.7	30.0
		% within Respondent distance to the River	93.3%	6.7%	100.0%
	301 - 500 Meters	Count	32	0	32
		Expected Count	31.3	.7	32.0
		% within Respondent distance to the River	100.0%	0.0%	100.0%
	501 - 700 Meters	Count	17	0	17
		Expected Count	16.6	.4	17.0
		% within Respondent distance to the River	100.0%	0.0%	100.0%
	701 - 900 Meters	Count	2	0	2
		Expected Count	2.0	.0	2.0
		% within Respondent distance to the River	100.0%	0.0%	100.0%
	More than 900 Meters	Count	1	0	1
		Expected Count	1.0	.0	1.0
		% within Respondent distance to the River	100.0%	0.0%	100.0%
Total		Count	87	2	89
		Expected Count	87.0	2.0	89.0
		% within Respondent distance to the River	97.8%	2.2%	100.0%

Table 4.9 shows that 75.82% of the respondents lived within 500 metres of River Nyando. Only 24.18% of the respondents lived beyond 500 metres of the river. A vast majority,

(97.8%) had experienced floods. These findings are vital because they reveal the level of vulnerability and risk of the households to the effects of flooding. This settlement pattern agrees with a study by Masese *et al.* (2016) who established that some residents risked by living close to the river simply because floods provided rich alluvial fertile soil for their crops, plenty of fish, water for domestic use and irrigation, and relief from NGOs, government and other stakeholders.

4.5.7.2 Households' proximity to River Nyando Inferential Analysis

The data was analyzed using a Chi-square test of association, with a probability of error threshold being p=0.05, based on the null and alternative χ^2 –statistic.

$H_0$1: Household proximity has no association with livelihoods affected by floods in Kano plains (Null Hypothesis)

Ha2: The two variables under consideration are associated (Alternative Hypothesis)

Table 4. 10: Households' proximity to River Nyando Inferential Statistics

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.024[a]	5	.546
Likelihood Ratio	4.441	5	.488
N of Valid Cases	89		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .02.

There was no significant association between households' proximity and livelihoods affected by floods in Kano plain; **χ^2 (5, N=89) =** 4.024[a], P = 0.546. The lack of statistical association between the two variables was confirmed through Likelihood ratio, p=0.488, due to the assumption that all cells should have expected the counts to be equal to or greater than five, as depicted in Table 4.10, which shows that 8 cells (66.7%) had expected count of less than 5. The minimum expected count is 0.02.

4.5.8 The Influence of Types of Housing to Floods Vulnerability

The nature and structure of housing determines, to some extent, their level of vulnerability and/or resilience to the effects of floods. The housing structure also gave an indication on the households' economic status. Table 4.11 and 4.12 shows the types of housing and the ownership status by the respondents.

Table 4. 11: Types of housing owned by the Respondents in Kano Plains

Type of housing	Frequency (n=91)	Percentage (%)
Permanent house	17	18.68
Temporary house	74	81.32
Total	**91**	**100.00**

(Source: Author, 2019)

Table 4. 12: Housing status owned by the Respondents in Kano Plains

Housing status	**Frequency (n=91)**	**Percentage (%)**
Owned house	87	95.60
Rented house	4	4.40
Total	**91**	**100.00**

(Source: Author, 2019)

Table 4.11 shows that majority (81.32%) of houses in the study area were temporary. The permanent houses were only 18.68%, and out of that, 95.60% of the houses were owned by the respondents, and only 4.40% were being rented (Table 4.12). The temporary houses were houses with walls of mud, while the permanent houses were constructed with stones and/or bricks. This finding implies that a majority of respondents' houses were temporary, and therefore bound to increase vulnerability in the event of a flood occurrence. This is because the materials used would not be able to withstand the destructive force of floods; and this finding is similar to a study by Nyakundi *et al.* (2010), who found housing quality index an important indicator of flood vulnerability.

4.5.8.1 Housing Structures to Floods Vulnerability Descriptive Analysis

A three-way contingency table (Table 4.13) was conducted to evaluate whether households' structures was associated to livelihoods affected by floods in Kano plain.

Table 4. 13: Housing Structures to Floods Vulnerability Contingency in Kano Plains

Average monthly income in Kenyan shillings				Livelihood affected by floods Yes	No	Total
10,000 and Less Shillings	House structure	Permanent	Count	2	1	3
			Expected Count	2.9	.1	3.0
			% within House structure	66.7%	33.3%	100.0%
		Temporary	Count	27	0	27
			Expected Count	26.1	.9	27.0
			% within House structure	100.0%	0.0%	100.0%
	Total		Count	29	1	30
			Expected Count	29.0	1.0	30.0
			% within House structure	96.7%	3.3%	100.0%
10,001 - 20,000 Shillings	House structure	Permanent	Count	4	0	4
			Expected Count	3.9	.1	4.0
			% within House structure	100.0%	0.0%	100.0%
		Temporary	Count	24	1	25
			Expected Count	24.1	.9	25.0
			% within House structure	96.0%	4.0%	100.0%
	Total		Count	28	1	29
			Expected Count	28.0	1.0	29.0
			% within House structure	96.6%	3.4%	100.0%
20,001 - 30,000 Shillings	House structure	Permanent	Count	8		8
			Expected Count	8.0		8.0
			% within House structure	100.0%		100.0%
		Temporary	Count	16		16
			Expected Count	16.0		16.0
			% within House structure	100.0%		100.0%
	Total		Count	24		24
			Expected Count	24.0		24.0

			% within House structure	100.0%		100.0%
Over 30,000 Shillings	House structure	Temporary	Count	4		4
			Expected Count	4.0		4.0
			% within House structure	100.0%		100.0%
	Total		Count	4		4
			Expected Count	4.0		4.0
			% within House structure	100.0%		100.0%
Total	House structure	Permanent	Count	14	1	15
			Expected Count	14.7	.3	15.0
			% within House structure	93.3%	6.7%	100.0%
		Temporary	Count	71	1	72
			Expected Count	70.3	1.7	72.0
			% within House structure	98.6%	1.4%	100.0%
	Total		Count	85	2	87
			Expected Count	85.0	2.0	87.0
			% within House structure	97.7%	2.3%	100.0%

Table 4.13 indicates majority, 72 (82.76%) of Kano plains residents lived in temporary houses of which 27(37.50%) and 24(33.33%) had experienced floods and had Less than 10,000 Shillings and between 20,000 to 30,000 Shillings as their monthly income respectively.

4.5.8.2 Housing Structures Vulnerability to Floods Inferential Statistics

Table 4. 14: Housing Structures to Floods Vulnerability Inferential Statistics

Average monthly income in Kenyan shillings		Value	Df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Less than 10,000 Shillings	Pearson Chi-Square	9.310[c]	1	.002		
	Continuity Correction[b]	1.839	1	.175		
	Likelihood Ratio	4.950	1	.026		
	Fisher's Exact Test				.100	.100
	N of Valid Cases	30				
10,001 - 20,000 Shillings	Pearson Chi-Square	.166[d]	1	.684		
	Continuity Correction[b]	.000	1	1.000		
	Likelihood Ratio	.302	1	.582		
	Fisher's Exact Test				1.000	.862
	N of Valid Cases	29				
20,001 - 30,000 Shillings	Pearson Chi-Square	.[e]				
	N of Valid Cases	24				
Over 30,000 Shillings	Pearson Chi-Square	.[f]				
	N of Valid Cases	4				
Total	Pearson Chi-Square	1.540[a]	1	.215		
	Continuity Correction[b]	.086	1	.769		
	Likelihood Ratio	1.157	1	.282		
	Fisher's Exact Test				.317	.317
	N of Valid Cases	87				

a. 2 cells (50.0%) have expected count less than 5. The minimum expected count is .34.

b. Computed only for a 2x2 table

c. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .10.

d. 3 cells (75.0%) have expected count less than 5. The minimum expected count is .14.

e. No statistics are computed because Livelihood affected by floods is a constant.

f. No statistics are computed because House structure and Livelihood affected by floods are constants.

The group who had a monthly income of less than 10,000 showed statistical association of the two variables (Housing structures and livelihoods affected) was confirmed by Likelihood ratio, p=0.026, due to the assumption that all the cells should have expected the counts to be equal to or greater than five, as depicted in Table 4.14, which shows that 3 cells (75.0%) have expected a count of less than 5. The minimum counts expected should be 0.10. There was a partially significant association between households' housing structures and livelihoods affected by floods in Kano plain; $\boldsymbol{\chi^2}$ **(1, N=87) = 9.310**^{c}, P=.002.

The Chi-square is a significant statistic, and should be followed with a strength statistic. To measure the association between categorical variables that include more than two levels, Cramér (1946) recommended the following statistic, commonly referred to as Cramér's V or Cramér's phi: φC = square root of (χ 2 / N(L – 1)). The study found out that phi and Cramer's V registered a partial significance of P=0.002, which implies that the null hypothesis is rejected, and affirming that there was a partial significant association between house structures and livelihoods affected by floods in Kano plains, specifically among those earning less than 10,000 shillings per month.

The findings here correlate with the study by Okayo *et al*. 2015 who found low income households chose precautionary measures reflecting limited financial reserves while medium to high income households preferred coping strategies that increase their financial reserves, consequently shielding them from flood related losses.

4.5.9 Sources of Livelihood

The sources of livelihood of respondents was considered an important factor to this study as it indicated the level and scale of income earned which had a significant influence in the ability to cope with floods (Fig 4.15).

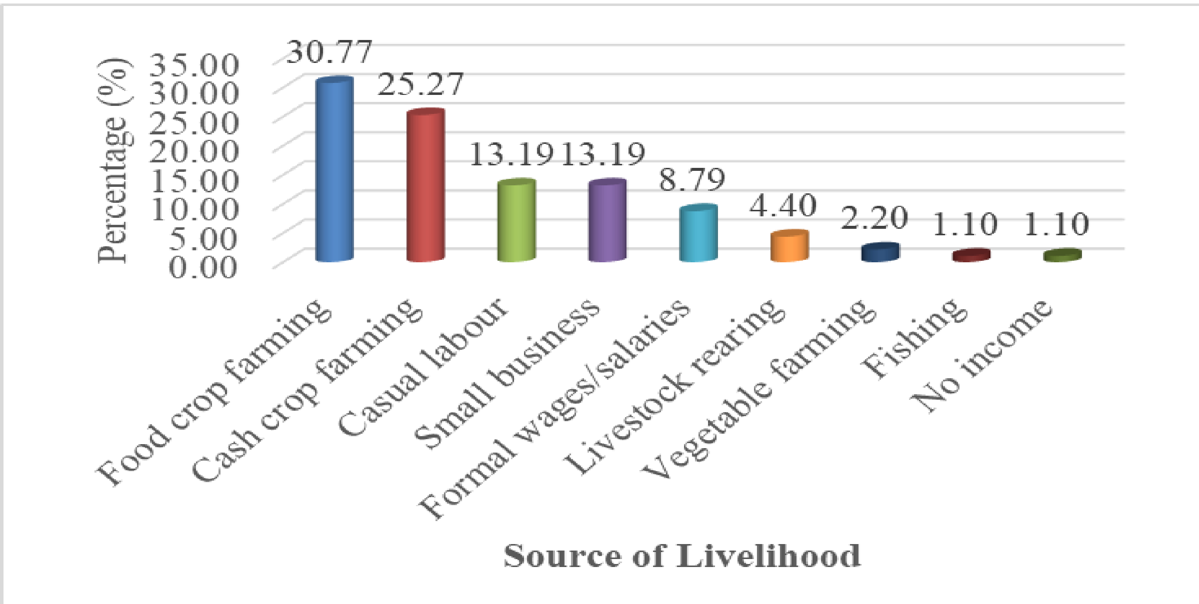

Figure 4. 15: Sources of livelihood of the Respondents in Kano Plains
(Source: Field survey, 2019)

The main sources of income of the respondents were food crop farming (Rice, maize, sorghum and millet) with 30.77%, followed by cash crop farming (25.27%), casual laborers (13.19%), petty trade (13.19%), formal wages (8.79%), Livestock rearing (4.40%), vegetable farming (2.20%), fishing (1.10%), and 1.10% with no income at all. A majority of the respondents were found to be operating on small scale based on the capital amount used to start and run the businesses. The findings indicated that a majority (69.23%) living in the Kano flood plain earned a monthly income of less than Ksh. 20,000 as detailed in Figure 4.4 thus was exacerbating their vulnerability to floods. SERA Project

(2002), similarly found a correlation between household resources and flood vulnerability to be that coping with and recovery from flood impacts both demand financial reserves that can cushion the household from negative flood impacts.

4.6 Effects and Vulnerability of Floods in Flood Risk Areas of Kano plains

The study found out that (97.80%), 89 of 91 of the respondents had experienced flooding in Kano plains, with only 2.20% who had not been affected by floods, Table 4.15. On the effects and vulnerability to floods, the study considered properties destroyed, such as houses, crops, livestock businesses, deaths from flooding, and effects on infrastructure such as roads.

4.6.1 Properties Destroyed during the Floods

Respondents were asked about what household properties were damaged or destroyed by floods during the flood incidences. Their responses were as summarized in Table 4.15.

Table 4. 15: Property of the Respondents Destroyed by Floods in Kano Plains

Property Affected/Destroyed	Frequency (f=89)	Percentage (%)
House and household properties	62	69.66
Farm Land/crops	16	17.98
Loss/injury on livestock	6	6.74
Shop/Business properties	3	3.37
Loss/injury on human life	2	2.25
Total	**89**	**100.00**

(Source: Author, 2019)

(Note: n=89 because the 2 (2.20%) of respondents admit to have not experienced foods and had no property destroyed).

It is evident from the results in Table 4.15 that 69.66% of the respondents lost or got their houses and household properties destroyed, while 17.98% lost farm land/crops. Those with loss/injury on livestock were 6.74%, those whose shops/Business properties were destroyed were 3.37%, and loss/injury of human life was 2.25%. These findings correspond with that of Keller (2001), who noted that flood impacts include damages caused by flooding and those caused by the disruption and malfunctioning of services and systems associated with flooding. Primary effects of floods include injury and loss of life, damages caused by floods to homes, communication networks and buildings, while secondary impacts include short-term turbidity of the river, hunger, disease, and displacement of people from their homes.

One respondent from Kanyagwal village in Nyando sub-County said during a key informant interview when asked about the effects of floods:

> *"In Nyando, floods wash away our farmlands, thus resulting to food losses and hunger as well as our socio economic livelihood, since this is an area where we practice horticulture highly. There is need to harvest this storm water for economic empowerment especially since this area has a high potential for horticulture. Floods also destroy our farmlands and cause loss of human and animals' lives as well as destruction to homes. They disrupting daily living, education and hinder livelihoods" (KII 13th May 2019).*

In Miwani sub-location, where the people's main socio-economic activities were growing of sugarcane and rice plantations, the respondents said that floods washed off their crops and caused major setbacks financially and rendered them food insecure.

The respondents were also asked to quantify their losses in the most recent flood event, and their estimates were as given in Table 4.16.

Table 4. 16: Quantity of Property of the Respondents Destroyed by Floods in Kano Plains

Quantity of losses (Ksh)	Frequency (f=89)	Percentage (%)
10,000 and less	18	20.23
10,001 – 20,000	16	17.98
20,001 – 30,000	26	29.21
Over 30,000	29	32.58
Total	**89**	**100.00**

(Source: Author, 2019)

Results in Table 4.16 show that 32.58% of the respondents lost properties of over Kshs 30,000, followed by 29.21% that lost property between Kshs 20,001 - 30,000, then 20.23% lost Kshs 10,000 and less, and 17.98% lost between Kshs 10,001 - 20,000. This finding implied that the losses incurred rendered households more vulnerable to flooding, and this agrees with the findings by Masese *et al*. (2016), who found that populations were more vulnerable to flood events as a result of significant losses incurred.

4.6.1.1 Effects of Floods on Homesteads and Infrastructure

The study found out that some of the effects of floods on homesteads and infrastructure in the study area were as shown in Plate 4.1 and Plate 4.2.

Plate 4. 1: Destruction of a house due to effects of flood in Magina (Source: Author May, 2019)

Plate 4. 2: Effects of flood on roads in Magina (Source: Author May, 2019)

From the transect walk, a number of roads and social amenities like schools and hospitals were found damaged by floods. Residents also talked of disruption of power lines and telephone communication networks, during heavy floods. The photos were taken in May 2019 after the short season rains for ease of identification of areas prone to floods. Masese *et al* (2016), similarly reported that damage to infrastructure not only exacerbates impact of flood disasters, but also creates problems in the evacuations of the affected population.

4.6.1.2 Effects of Floods on Water Sources and Energy for Cooking

The study found out that the effects of floods to water sources and cooking energy were as shown in Table 4.17.

Table 4. 17: Respondents' Sources of Water and Energy for Cooking in Kano Plains

Water/Energy	Frequency (n=91)	Percentage (%)
River	81	89.01
Borehole	7	7.69
Piped	2	2.20
Other	1	1.10
Total	**91**	**100.00**
Firewood	76	83.52
Charcoal	9	9.89
Kerosene	4	4.40
Gas	2	2.20
Total	**91**	**100.00**

(Source: Field survey, 2019)

89.01% of the respondents depended on River Nyando as their source of water, while 7.69% cited boreholes as their source of water and 2.20% and 1.10% cited piped water and rain water as their sources of water respectively. The findings here correlate to the results from a study by Nyakundi *et al* (2010) which discovered that most of the residents experienced shortages of clean water for domestic use during floods.

Concerning energy for cooking, firewood was mentioned by 83.52% as their main source of energy. This was followed by charcoal (9.89%), kerosene (4.40%), and finally gas (2.20%). From these findings, it is clear that the majority of the respondents depended on firewood as their source of energy, and these were obtained from the nearby bushes and shrub. Therefore, during floods, the respondents had nowhere to collect the firewood. In addition, the clearance of the bushes and shrubs predisposes the area to severe flood vulnerability, due to lack of vegetation to reduce the speed of flood water run-off. These findings agree with those by Olang and Furst (2011) that indicated deforestation in the Kano plains as contributing factor to floods vulnerability.

4.6.1.3 Effects of Floods on Sanitation

97.80% of the respondents used pit latrines, with only 2.20% who could afford flush toilets (Figure 4.16). This implies that a majority of the population would be affected by water-borne diseases due to poor sanitation in the event of floods. This agrees with the findings of a study by Masese *et al.* (2016), who also found out that there is often an upsurge of water borne diseases attributed to unsafe water sources and flooded sanitation facilities.

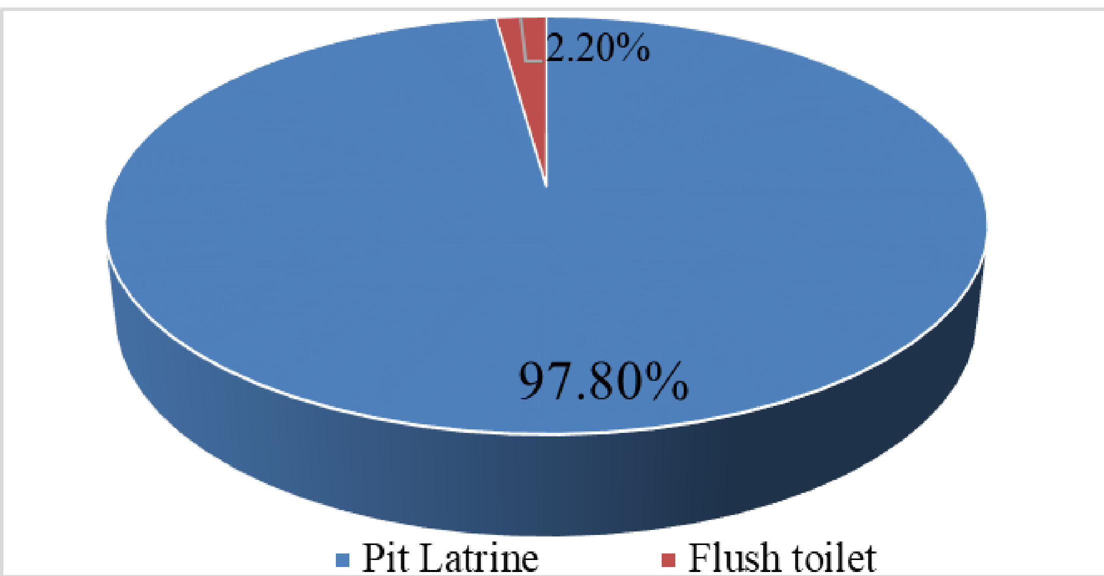

Figure 4. 16: Sanitation situation in Kano Plains (Source: Field survey, 2019)

One participant from the FGD held in Lower Nyakach sub location said:

> *"During floods, our pit latrines are swallowed up in the water and the contents swept off by the run off and this increases the cases of diarrhea and bilharzia and livestock diseases which are hard to treat especially during these long rain seasons" (FGD 13th May 2019).*

4.7 Effectiveness of Existing Mitigation Measures for Flood Management in Lower Kano Plains

The study evaluated the effectiveness of existing flood management measures that are being used in the study area, by direct observation, and taking of photographs of dykes, waterways, and canals, among other methods. This set of data was to complement data obtained through questionnaires, key informant interviews, and focus group discussions. Other strategies and systems used to create floods risk awareness and management by government and other institutions and organizations, were also interrogated. In addition, the study evaluated government support programmes and local community flood awareness and their preferred coping strategies. Barriers to effective mitigation measures were also discussed.

Some structural flood mitigation measures employed in Nyando included constructed dykes, water channels and water pans. These were as shown in the plates 4.3 and 4.4 below.

Plate 4. 3: Constructed dykes on river Nyando in Magina area (Source: Author May, 2019)

Plate 4. 4 Gabions built along river Nyando banks at Magina

(Source: Author May, 2019)

Some of the water channels constructed had been destroyed and needed improvement which was yet to be done, and from the key informant interviews, this was attributed to various challenges such as inadequate funding and lack of continuity and consistency. One respondent during a key informant interview said:

> *"One major challenge in mitigating floods in Nyando is funding. There is need for the government to allocate enough resources to manage floods. We need more resources to construct more channels and dykes, evacuation centers and develop Flood Management Plans for these places (KII with Water Resource Authority officer 11th May 2019)"*

Similarly, Flood Mitigation Strategy (2009) reported that some of the physical measures to mitigate impacts of floods, such as low level dykes, check dams and diversion channels protecting agricultural fields, and some soil conservation strategies, had been destroyed. The non-structural flood mitigation measures that came up from the study were programs on awareness creation and early warnings, livelihood programs to improve the income of the people and Flood Management Plans, mostly done by the government and some NGOs. Suggestions on training the community on disaster preparedness were also mentioned.

Among constraints in the current disaster management efforts identified by JICA, 2009 report were; a lack of well-trained personnel, duplication of flood management efforts by related organizations due to conflicting mandates and weak cohesion.

The study established that several channels were used to create flood awareness and management (Figure 4.17).

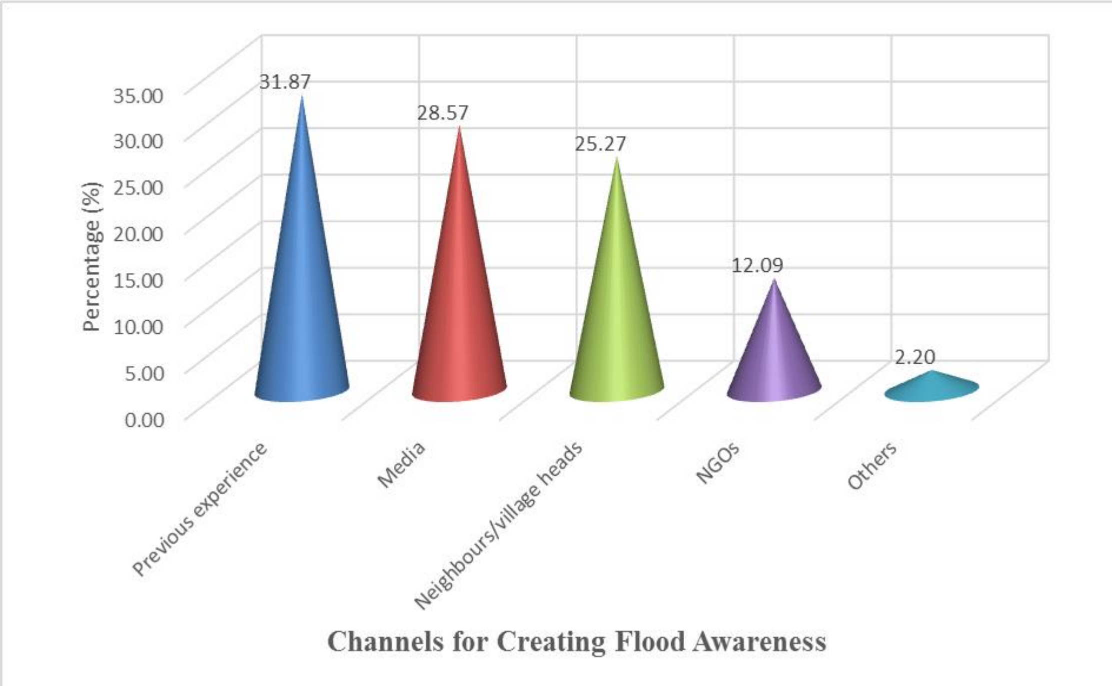

Figure 4. 17: Channels for creating Flood awareness and Management (Source: Field survey, 2019)

Hazard awareness means the personal understanding of hazard information and its specific processes (Paton *et al*., 2008). The idea being that, the more one understands the process of hazards, the better placed he is to reduce vulnerability and in so doing also disaster risk (Paton *et al*., 2008).

Media (Radio) was found to be the most effective means through which the community got information on floods as most households owned a Radio, similar to the findings of Masese *et al.* (2016). Plate 4.5 shows a flood awareness poster indicating a flood hazard map in Miwani sub-County.

Plate 4. 5: A poster for flood hazard awareness map in Miwani sub-location (Source: Author May, 2019)

4.7.1 Support from the Government and other Institutions during Flood Events

73.63% of the respondents also said that they have not received any support from the government or other institutions and organizations during flooding in Kano flood plain; only 26.37% responded in the positive (Figure 4.18). These results concur with a study by Nyakundi (2010), who found that relief measures and programs were able to make communities more resilient to floods, and that communities would never accept to have gotten aid lest they are denied the assistance during floods in case they admit to have received aid.

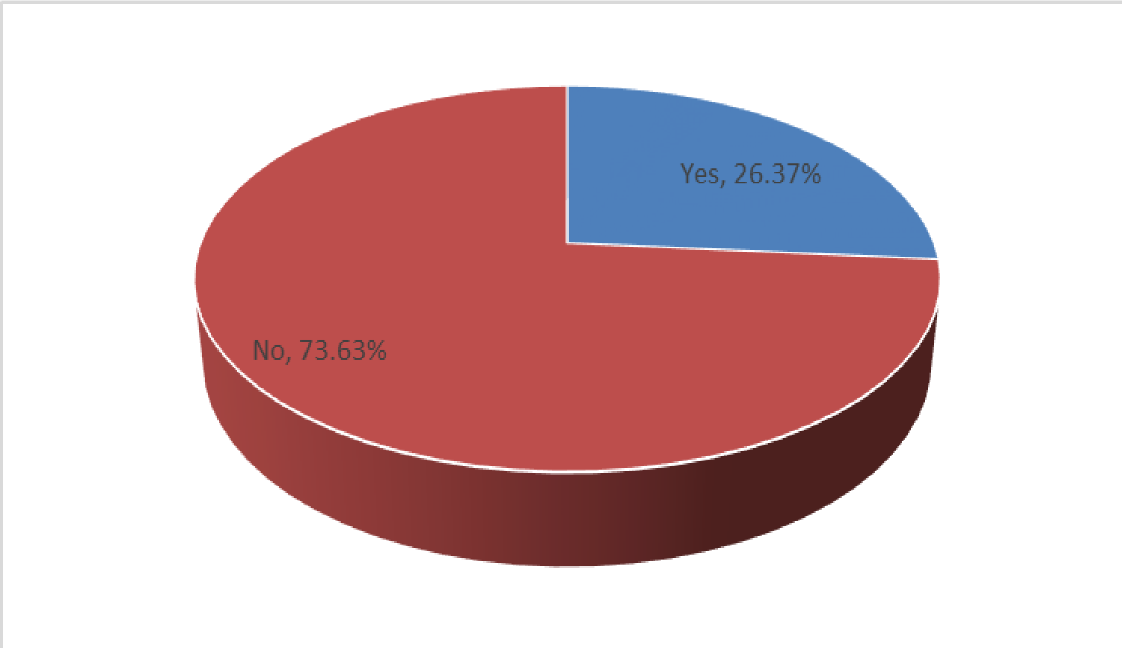

Figure 4. 18: Support from the Government and other Institutions and Organizations

(Source: Author, 2019)

Among those who admitted to have received support from the government and other institutions during flood events listed these organizations presented in Table 4.18.

Table 4. 18: Institutions and Organizations providing Support in Kano Plains

Institution/Organization	Frequency (n=24)	Percentages (%)
Kenya Red Cross	10	41.67
VIRED (NGO)	6	25.00
County Government	4	16.67
JICA	2	8.33
Administration Police	2	8.33
Total	**24**	**100.00**

(Source: Field Survey, 2019)

Note: f=24 because 73.63% declined to have any institutional support (refer to Figure 4.18) Frequency in Table 4.18 represents the 24 people interviewed out of the sample of 91.

The institutions and organizations in Table 4.18 provided different kinds of support, ranging from Evacuation Shelter (37.50%), Food (29.17%), and Non-food Items such as medicine, clothing, beddings, among others (25.00%), and other varied kinds of support (8.33%). the Kenya Red Cross provided evacuation shelters and food items, JICA constructed shelters, Kisumu County Government and the Administration Police offered food items, medicine and beddings, as well as security. VIRED offered food donations. The respondents who received different kinds of support from various institutions and organizations said they were Very satisfied (10.99%), Moderately satisfied (13.19%), and Not satisfied (75.82%).

One participant from the FGD held in Miwani sub-County reported:

> *"The Government and other NGOs like World Vision, JICA and The Kenya Red cross have been offering relief food and humanitarian assistance during floods. JICA has built and renovated some evacuation centers but these are never enough to offer asylum to the many number of people affected, and also some of the shelters and facilities constructed have overtime been destroyed by floods rendering us homeless again when floods reoccur" (FGD 14th May 2019).*

Plate 4.6 and 4.7 show an evacuation shelter and pit latrine built by JICA in 2010 at Miwani sub County and Magina area.

Plate 4. 6: A poorly maintained evacuation center constructed by JICA at Miwani sub-County in 2010 (Source: Author May, 2019)

Plate 4. 7: A raised pit latrine whose floor suffered damages from floods was constructed by JICA at Magina in 2010 (Source: Author May, 2019)

4.7.2 Effectiveness of Flood Mitigation Measures in Kano Flood Plain

In order to determine which flood coping strategies were effective and preferred by the local community, the researcher gave different statements on flood mitigation measures by adopting Likert scale standard deviation method (Appendix 1 section D9). Table 4.19 shows the flood mitigation measures as preferred by the respondents.

Table 4. 19 Flood Mitigation measures Preferred by the Respondents

Strategies	Very Large Extent		Large Extent		Neutral/ Undecided		Small Extent		Very Small/ No Extent		Total (%)	
	F	%	F	%	F	%	F	%	F	%	F	%
Use of early warning system	0	0.00	0	0.00	70	76.92	21	23.08	0	0.00	91	100.00
Crop Diversification	0	0.00	0	0.00	82	90.11	9	9.89	0	0.00	91	100.00
Moving away to safer place	78	85.71	13	14.29	0	0.00	0	0.00	0	0.00	91	100.00
Planting trees	32	35.16	28	30.77	31	34.07	0	0.00	0	0.00	91	100.00
Constructing dykes/dams/gabions	9	9.89	29	31.87	38	41.76	10	10.99	5	5.49	91	100.00
Constructing of strong permanent houses	0	0.00	0	0.00	23	25.27	68	74.73	0	0.00	91	0.00

(Source: Field survey, 2019)

The study realized that 76.92% of the respondents were undecided on the use of early warning system also interpreted by most of them as; traditional ways of predicting floods apart from the modern flood alert systems such as media and weather forecast, as a flood mitigation measure, and 23.08% preferred it to a small extent. Up to 90.11% of the respondents maintained that they had no idea of crop diversification as a flood mitigation measure; crop diversification improves soil fertility, consequently ensuring constant vegetative cover that would slow down surface run off. 85.71% of the respondents preferred to a large extent moving away to safer places during flooding period. The results here were contrary to a study by Okayo *et al*. (2015) who concluded that the community is complacent to flooding and how it affects them as long as relief is distributed to them since only a small number of the households are ready to move to higher ground, and that flood time is 'harvest' time and that some prohibiting factors to relocating during floods are livelihoods, land resource, culture and attitude. As far as the effectiveness of the flood mitigation measures employed in the Kano flood Plain were concerned, the responses by respondents were as indicated in Table 4.20.

Table 4. 20 Effectiveness of Flood Mitigation measures in Kano Flood Plain

Strategies	**Very Effective**		**Effective**		**Neutral**		**Less Effective**		**Not Effective**		**Total (%)**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Use of early warning system	0	0.00	0	0.00	9	9.89	0	0.00	90	90.10	91	100.00
Crop Diversification	0	0.00	2	2.20	89	97.80	0	0.00	0	0.00	91	100.00
Moving away to safer place	90	98.01	1	1.10	0	0.00	0	0.00	0	0.00	91	100.00
Planting trees	6	6.59	14	15.38	45	49.45	26	28.57	0	0.00	91	100.00
Constructing dykes/dams	91	100.00	0	0.00	0	0.00	0	0.00	0	0.00	91	100.00
Constructing of strong permanent houses	0	0.00	7	7.69	66	72.53	18	19.78	0	0.00	91	100.00

(Source: Field survey, 2019)

From Table 4.20, the study established that 90.10% of the respondents suggested that the existing early warning system is not effective at all while 9.89% were neutral as far as this flood mitigation measure was concerned. This could be attributed to the fact that communities were unwilling to heed to these warnings as it meant a disruption in their normal lives.

Regarding crop diversification as a flood mitigation measure, 97.80% of the respondents were undecided, with only 2.20% of the respondents admitting that measure was effective. On moving to safer places as a flood mitigation measure, 98.01% of the respondents agreed that it is very effective. Nevertheless, 100% of the respondents agreed that constructing dykes/dams was a very effective flood coping strategy. In terms of planting trees, 49.45% were undecided, with 28.57% suggesting it was less effective and 15.38% responded that it was effective. Construction of strong houses attracted varied opinions, with 72.53% being undecided, similarly Okayo *et al* (2015) found out that what this did not necessarily influence the level of uptake of precautionary measures but rather communities were influenced by distance, household composition, income and social networks to uptake precautionary measures.

4.7.3 Opportunities and Barriers for Flood Vulnerability Reduction in Kano Plains

Concerning the opportunities and barriers for vulnerability reduction in flood prone areas of the Kano Plains, which may influence effectiveness of flood mitigation measures, the study obtained the results given in Table 4.21.

Table 4. 21: Opportunities for Flood Vulnerability reduction in Kano Plains

Opportunity	Strongly Disagree		Disagree		Undecided		Agree		Strongly Agree		Total (%)	
	F	%	F	%	F	%	F	%	F	%	F	%
We have a cohesive community	8	8.79	9	9.89	6	6.59	38	41.76	30	32.97	91	100.00
We have good/situated knowledge	2	2.20	7	7.69	9	9.89	50	54.95	23	25.27	91	10.00
We have government support	7	7.69	17	18.68	13	14.29	33	36.26	21	23.08	91	100.00
We have other institutional support	2	2.20	8	8.79	41	45.05	30	32.97	10	10.99	91	100.00

(Source: Field survey, 2019)

From Table 4.21, 41.76% of the respondents agreed that a cohesive community was an opportunity for flood vulnerability reduction; while 32. 97% strongly agreed. Whereas, 54.95% of the respondents agreed and 25.27% strongly agreed that good/situated knowledge about floods was an opportunity for flood vulnerability reduction in the study area; while 9.89% were undecided, 7.69 disagreed and 2.20% strongly disagreed. Even with these varied opinions, 36.26% of the respondents agreed to have government support, 23.08% strongly agreed, and 18.68% disagreed; whilst 14.29% of the respondents were undecided and 7.69% strongly disagreed. With regard to getting other institutional support, 45.05% were undecided 32.97% agreed, and 8.79% disagreed. The findings here corroborate that of Nyakundi (2010) on cohesive community and good/situated knowledge. However, results here differ significantly on the issue of government/ external support, Nyakundi (2010) found external/ government support to have a crucial role in cushioning the community against floods.

On barriers to flood vulnerability reduction in Kano Plains, the study obtained the results summarized in Table 4.22.

Table 4. 22: Barriers to Flood Vulnerability Reduction

Barrier	**Strongly Disagree**		**Disagree**		**Undecided**		**Agree**		**Strongly Agree**		**Total (%)**	
	F	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Weak institutions (government and NGOs	1	1.10	28	30.77	37	40.66	19	20.88	6	6.59	91	100.00
Local community cannot afford safer places	3	3.30	6	6.59	12	13.19	60	65.93	10	10.99	91	100.00
It is our Ancestral land	0	0.00	2	2.20	24	26.37	58	63.74	7	7.69	91	100.00

(Source: Field survey, 2019)

Table 4.22 shows that concerning weak institutions as a barrier to flood vulnerability reduction, 40.66% were undecided, 30.77% disagreed, whereas 20.88% agreed. This corroborate the findings of Nethengwe (2007), that cited weak institutional support a factor impeding flood disaster management in Milaboni and Dzihange areas in South Africa. Whereas, 65.93 of the respondents agreed that the community could not afford safer places. Also, 63.74% agreed that they were in their ancestral land and were not willing to move.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides the summary of findings, conclusion, and recommendations. Conclusion of the study is based on the objectives; while recommendations are based on data which was analyzed. Finally, the chapter proposes areas for further research.

5.2 Summary of Findings

The study found out that 65.93% of the respondents resided at the downstream of River Nyando, and of these, 60% resided in Nyando sub-County in areas such as Kabonyo, Kanyagwal, Ugwe, and Nyachira Siany, and 40.00% resided in Lower Nyakach sub-location. Respondents from Miwani sub-County were within the midstream of River Nyando. These were zones perceived to experience heavy flooding in Kano Plains. GIS analysis on the effects of geographical factors such as soil type, drainage pattern, slope, as well as land use on flooding revealed that these contribute significantly to flooding. These findings supported communities identified flood prone areas in Kano Plains. For instance, slopes in the study area were found to range between 0 degree on the shores of Lake Victoria, to a high of 34.86 degrees on the hills towards south western regions of the study area. A vast area of Kano Plain was found to have poorly drained clay soil that exacerbated flooding. On land use, it was found out that areas with plantations and swamps were significantly affected by floods.

Further, on the socio-economic determinants of community vulnerability to floods, the study found that gender was not a significant factor as the ratio of males to females affected by floods was almost similar, just as for education level of the respondents, since only 1.10% were found to have no formal education, for the former (gender), reason being modern gender roles are similar while for the later (education), the apathy in heeding precaution against floods being overreliance on aid from government and other well-wishers. It was established that income plays an important role in response to floods with a likelihood ratio of p=0.026. There was high dependency ratio in the study area with 71.43% households having between 4 - 9 members. Both the young and old were equally affected by floods. It was also established that houses headed by single parent were hard hit during floods.

Regarding the third objective, on effects and vulnerability of floods, the study found out that 97.80% of the respondents had been affected by flooding (Section 4.6, Table 4.15), and from the affected group, 69.66% lost or got their houses and household properties destroyed, other losses were farm land/crops destroyed, loss/injury on livestock, destroyed shops/business properties and loss/injury of human life. Other properties destroyed were infrastructure such as roads. 89.01% of the respondents depended on River Nyando for their source of water, with 7.69% depending on boreholes, 2.20% piped water and 1.10% rainwater. Firewood was the main source of cooking energy (83.52%), followed by charcoal (8.89%). 97.80% of the respondents used pit latrines with only 2.20% who could afford flush toilets. As far as the type of housing for the respondents was concerned, 81.32% were temporary, and only 18.68% were permanent and this presented a potential vulnerability to floods. The study also found that 75.82% of the respondents lived within 500 meters of River Nyando, which represented a high risk and vulnerability during floods.

On the fourth objective, to evaluate the effectiveness of existing mitigation measures for flood management, it was established that 76.92% of the respondents were undecided on use of early warning system as a flood coping strategy. Up to 90.11% of the respondents maintained that they had no idea of crop diversification as a flood coping strategy, while 85.71% of the respondents preferred to a large extent on moving away to safer places during flooding period. 90.10% of the respondents suggested that the existing traditional early warning system is not effective at all, for the birds they used to rely on were no more, while 9.89% were neutral as far as this flood coping strategy was concerned. Nevertheless, 100% of the respondents agreed that constructing dykes/dams was a very effective flood coping strategy. In terms of planting trees, 49.45% were undecided, with 28.57% suggesting it was less effective and 15.38% responded that it was effective. Construction of strong houses attracted varied opinions, with 72.53% of the respondents being undecided.

5.3 Conclusions

Based on the findings outlined above, the following conclusion was arrived at:

i. Miwani, Nyando and Lower Nyakach at the mid and downstream of River Nyando were found to be the flood risk areas in the Nyando sub-catchment. This was attributed to the settlement pattern along the main tributaries of Nyando due to the perceived benefits associated with it, such as close proximity to water source and rich alluvial soils for farming.

ii. Household, income and cohesive community were found to be major factors determining community vulnerability to floods, with those having higher incomes and communities closely knitted together in sharing their knowledge and experiences found to be coping better during flood events.

iii. Loss of farmland, houses and property were found to be the most serious effects of floods, due to the fact that a majority of the respondents stayed along the river in temporary houses, and this also made them potentially much more vulnerable to floods.

iv. Construction of dykes/dams and getting government and other institutional support were found to be very effective flood coping strategies, since a majority of the respondents were in their ancestral lands and could also not afford to move to safer places.

5.4 Recommendations

From the findings presented in this study, the researcher came up with the following recommendations:

i. There is need for an integrated approach for effective flood~~s~~ management by merging scientific methods with local knowledge; the government should take lead on this.

ii. Communities should be guided on the best ways to increase resilience by engaging in livelihood strategies that improve their incomes at the same time safeguarding the natural resources in order to be better placed to cope with floods.

iii. The government as well as other supporting agencies need~~s~~ to strengthen programmes that target education and awareness creation on the best and cost effective ways of coping with floods and other associated disasters. Methods that will help reduce the pressure on land which is a major casualty of floods, and improve economic empowerment.

iv. There is need for collaboration between the County Government and National Government in the development and enforcement of relevant by-laws in the use and management of the flood plains.

5.5 Suggestions for further Research

The study proposes the following areas for further research:

i. Flood mitigation and management strategies using early warning systems.

ii. Community management systems for flood~~s~~ mitigation and management: the case of local perceptions and indigenous knowledge.

iii. An assessment of the effectiveness of structural flood mitigation measures in flood plains.

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APPENDICES

Appendix 1: Questionnaire for Households

Hello,

Good morning/afternoon

My name is **Naomi Odero** a student of Master of Science in Integrated Watershed Management in Geography Department of Kenyatta University, Nairobi. I am undertaking a research study entitled, **"Socio Economic Determinants for Integrated Floods Management for Vulnerability Reduction in Lower Kano Plains, Kisumu County, Kenya"** I would thus like to ask you a few questions to help realize my study objectives. The information you give will be confidential and is intended solely for the writing of my M.Sc. Thesis.

Your time and participation in this study is much appreciated.

GPS Coordinates …………………………………………………………………..

SECTION A: DEMOGRAPHIC CHARACTERISTICS			
A1	What is your river zone?	Upstream … 1 Mid-stream …2 Downstream …. 3	
A2	Which Division do you reside in?	Miwani …1 Nyando … 2 Lower Nyakach …. 3	
A3	What is your gender?	Male .....1 Female ... 2	
A4	What is your age bracket?	Less than 19 Yrs …..1 19 – 40 Yrs ………. 2 41 – 60 Yrs ………. 3 Above 60 Yrs … 4	
A5	What is your Marital Status?	Single…1 Married…2 Divorced…3 Widowed…4 Separated…5	

A6	How many are you in your household?	Less than 4 ….1 4– 9 ……… 2 10 – 15 ……… 3 More than 15... 4	
A7	What is your Level of education?	Never attained formal education....... 1 Primary ... 2 Secondary ... 3 College/University.... 4	
A8	For how long have you lived in this area? *(Not necessarily in this house)*	Less than 1 year…1 1 - 3 years…2 4 - 5 years…3 Above 5years…4 Resident by birth…5	
A9	What motivated your move to this location? *(If migrated)*	Pasture …1 Safety from floods…2 Land Availability…3 Access to water …4 Other Specify…5	
A10	How far away is your home from the stream, river? (In Meters)	Less than 100m …..1 100 – 300m ………2 301 – 500m …..…. 3 501 – 700m …..…. 4 701 – 900m ……... 5 Above 900m ……. 6	
SECTION B: HOUSING			
B1	Is your house rented or owned?	Rented ….. 1 Owned…... 2	
B2	What is your main water source?	Piped …………….1 Borehole ……….. 2 River …………….3 Other (Specify) … 4	
B3	What is your main source of energy for cooking	Firewood ……....1 Charcoal ………. 2 Gas ……………..3 Cooking Stove, Kerosene ….4 Other (Specify) …….5	
B4	What is your House structure	Permanent ….. 1 Temporary ….. 2	
B5	What is your Sanitation?	Flush toilet …… 1 Pit latrine ……... 2	
SECTION C: ECONOMIC FACTOR			

C1	What type of ownership is your land?	Inherited family land…1 Leased…2 Rented…3	
C2	What is your source of livelihood?	Fishing...1 Livestock rearing...2 Food crop farming...3 Cash crop farming ...4 Casual labour...5 Petty trade/small business...6 Formal salary/wages...7 Vegetable farming /sales...8 No income source...9 Other (specify) 10	
C3	What is your average monthly income in Kenya shillings?	Less than 10,000 …. 1 10,000 – 20,000 ...... 2 20,001 – 30,000 ….. 3 Above 30,000 ……. 4	
C4	How many people in your household depend on your income?	3 and less …….. 1 4……………. 2 5……………. 3 6……………. 4 7……………..5 8 and more …. 6	
C5	Has your livelihood been affected by the floods?	Yes…1 No…2	
C6	If Yes, in what ways?	House …… 1 Land …….... 2 Shop or Business ……3 Health ……………….4 Livestock …………… 5 Crops ……………….. 6 Other ……………….. 7	
C7	Can you quantify your loss in Kenyan shillings?	Less than 10,000 …. 1 10,000 – 20,000 ...... 2 20,001 – 30,000 ….. 3 Above 30,000 ……. 4	
C8	What have you done to mitigate your loss?	Use of early warning system ....1 Crop Diversification ....2 Moving away to safer place ....3 Planting trees ....4 Constructing dykes/dams/gabions ....5 Constructing of strong permanent houses ....6 Turned to family, friends or government for help ......7 Any other 8	

C9	What influenced your choice in C8 above?	Cost of mitigation ......1 Urgency...2 Past experience ...3	
SECTION D: GOVERNMENT AND INSTITUTIONAL INTERVENTIONS			
D1	How do you get information on flood risk?	Neighbors…1 Government and Civil Society workers…2 Previous experience…3 Media…4 Other (specify)…...5	
D2	Have you received any support on floods from any officers or partners?	Yes …1 No…2	
D3	If Yes, who are they?	Government ......1 NGOs ....2 CBOs 3	
D4	In what ways have they supported you?	Evacuation/Shelter...1 Food...2 Non-food items, medicines, beddings...3 Reconstruction/rehabilitation...4 Awareness...5 Other (specify) …… 6	
D5	How contented are you with the support?	Very satisfied…..1 Moderately satisfied….2 Not satisfied….3	
D6	Reason for your satisfaction or dissatisfaction?		
D7	Are you aware of any mitigation measures that your community has put for floods?	Yes…1 No…2	
D8	If Yes, what are these mitigation measures?	Reforestation/Plantation...1 Proper land use practices...2 Early warning system...3 Structural adjustments like dams, dykes...4 Construction of proper housing...5 Other (specify) ………………... 6	

D9	How effective are these mitigation measures?	Very effective…1 Neutral..2 Not effective…3	
D10	If Yes, do you have any suggestions for their improvement?	(a) (b) (c) (d)	

SECTION E: OPPORTUNITIES AND BARRIERS FOR VULNERABILITY REDUCTION

After you read each of the opportunity and barrier, evaluate in relation to your situation in Kano flood plain. Put a tick ( ) as appropriate to you.

Key: 1: Strongly Disagree, 2: Disagree, 3: Undecided, 4: Agree & 5: Strongly Agree

E1	**Opportunity for integrated flood management approach**	1	2	3	4	5
	We have a cohesive community					
	We have good/situated Knowledge					
	We have Government support					
	We have civil Society support					
	Other (Specify and rate)					
E2	Reasons for the response above	(a) (b) (c) (d) (e)				
E3	**Barriers against integrated flood management approach**	1	2	3	4	5
	Weak institutions, i.e., government and Civil Society					
	Our community members cannot afford safer places					
	c) Our community members are not willing to leave their ancestral land					
	Others (Specify and rate)					

E4	Reasons for the response above	(a) (b) (c)

Appendix 2: Key Informant Interviews with NGOs/Government officials

1. Which organization do you work with?

2. What is the nature of your work?

3. For how long have you been working here?

4. Briefly describe the nature of flood occurrences in Kano Plains

5. Which are the main areas where you work?

6. Which are the key causes of inundations in the flood plain? (Rank the options, 1= very important, 5= least important)

   i. Deforestation or poor land use practices
   ii. Rains (climate change)
   iii. Cultural habits
   iv. Urbanization in flood plains
   v. Poor water management (river barriers)
   vi. Other -------------

7. Briefly explain the reason for your ranking above.

8. How can floods be lessened? (Rank the options, 1= very important, 5= least important)

   i. Plantations/reforestation
   ii. Proper land use practices
   iii. Sustainable agricultural practices
   iv. Early warning systems
   v. Water management
   vi. Construction of dams

vii. Other -------------

9. Explain briefly the reason for your ranking above.

10. Do you work in collaboration with other agencies?

11. Which ones are they? (*Government and other local bodies, Non-governmental organizations, Community*)

12. What has been their role in flood risk reduction?

13. Briefly describe the socio-economic settings of the people?

14. How prepared are they in the event of flooding?

15. What are your main successes?

16. What are the challenges?

17. Any suggestions over improving the livelihood of the people?

Thank you for participating in this interview.

Appendix 3: Focus Group Discussions guide

Theme: Socio economic determinants of Integrated Flood Management

1. Briefly describe the pattern of floods in this area.
2. How has this affected your life?
3. Are there any changes in the way these floods occurred?
4. What risks do these floods pose to you and your family?
5. Are there groups that are much more at risk? Maybe children and women?
6. What actions do you take in the event of floods?
7. Are there strategies in place for flood mitigation?
8. Who initiated these strategies, and how?
9. What do you as individuals do to mitigate floods?
10. What influenced the choice of mitigation measure you chose?
11. Has the community jointly worked in floods mitigation?
12. In what ways?
13. Are there ways in which you know when floods will hit? Give details.
14. What suggestions generally do you have on how best to deal with floods?

Thank you for participating in this FGD.

Appendix 4: Mental Mapping Schedule

In this exercise, participants were asked to use their past experiences to identify and demarcate flood prone areas. After orienting the participants and identifying their exact location, they were asked to embark on the mental mapping exercise by;

1. Placing a tracing paper on the topo map.
2. Drawing on the tracing paper the boundaries of the areas affected by floods.
3. Identifying each area according to the flood intensity (very severe, severe, moderate, etc.) as well as spatial-based socio-economic activities and labeling them appropriately.
4. Identifying some key landmarks identifiable on the topo map, with known geographical coordinates/references, to serve as control points. Examples of these are; schools, hospitals and other social amenities.

Plate 8: Lower Nyakach sub-County members being oriented for a community mapping exercise

Appendix 5: Field Observation Guide during Transect Walks with Village Heads

Date ____

Land use	
Land tenure system	
Type of housing	
Availability of Infrastructure, e.g. schools, hospitals, feeder roads	
Evidence of flooding e.g. water pools, damaged roads, houses and other infrastructure	
Availability of structural flood mitigation measures in place	
Availability of non-structural flood mitigation measures such as flood plain zoning, flood forecasting and warning systems	
Topography, e.g. slope, soils type, vegetation type	

Thank you for participating in this transect walk

Appendix 6: Reliability Test Statistics

Reliability Statistics

Cronbach's Alpha (α)	Cronbach's Alpha Based on Standardized Items	N of Items
.687	.758	6

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	α if Item Deleted
Age Of Respondents	13.91	15.091	.148	.169	.709
Household size	14.73	13.218	.700	.740	.621
Years that the respodent has lived in the area	12.91	11.891	.481	.295	.627
Average monthly income in kenyan shillings	14.45	12.873	.523	.722	.630
Household members dependant on the Respondent's income	13.73	6.418	.561	.736	.694
Quantity of losses to floods in Kenya shillings	13.45	12.473	.607	.740	.610

Intra-class Correlation Coefficient

	Intra-class Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.268[a]	.060	.608	3.197	10	50	.003
Average Measures	.687[c]	.275	.903	3.197	10	50	.003

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C interclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.

	c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.	

Source: Modified from Field (2019)

Appendix 7: Research Approval

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 020-8704150

Internal Memo

FROM: Dean, Graduate School

DATE: 26th March, 2019

TO: Ms. Naomi Auma Odero
C/o Department of Geography

REF: I56/33491/2014

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge receipt of your Research Proposal after fulfilling recommendations raised by the Graduate School Board of 6th March, 2019.

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed Supervision Tracking Forms per semester. The form has been developed to replace the Progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

Thank you.

EDWIN OBUNGU
FOR: DEAN, GRADUATE SCHOOL

CC. Chairman, Department of Geography

Supervisors:

1. Dr. Ishmail Mahiri
C/o Department of Geography
Kenyatta University

2. Dr. Kennedy Obiero
C/o Department of Geography
Kenyatta University

EO/cww

Appendix 8: Research Permit

THIS IS TO CERTIFY THAT:
MISS. NAOMI AUMA ODERO
of KENYATTA UNIVERSITY, 304-20400
BOMET,has been permitted to conduct
research in *Kisumu* County

on the topic: *SOCIO ECONOMIC DETERMINANTS OF INTEGRATED FLOODS MANAGEMENT IN LOWER KANO PLAINS, KISUMU COUNTY, KENYA*

for the period ending:
27th May,2020

Permit No : NACOSTI/P/19/68482/29794
Date Of Issue : 28th May,2019
Fee Recieved :Ksh 1000

....
Applicant's Signature

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

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

rant of Research Licenses is guided by the Science, ›logy and Innovation (Research Licensing) Regulations, 2014.

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cavation, filming and collection of specimens are subject to ther necessary clearance from relevant Government Agencies.
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NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/19/68482/29794**

Date: **28th May, 2019**

Naomi Auma Odero
Kenyatta University
P.O. Box 43844-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"*Socio economic determinants of integrated floods management in Lower Kano Plains, Kisumu County, Kenya*"** I am pleased to inform you that you have been authorized to undertake research in **Kisumu County** for the period ending **27th May, 2020.**

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.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kisumu County.

The County Director of Education
Kisumu County.