FLOOD RISK MAPPING AND FACTORS THAT MOTIVATE THE AFFECTED COMMUNITY TO CONTINUE LIVING IN THE FLOOD RISK ZONES IN BUDALANGI SUB-COUNTY, BUSIA COUNTY, KENYA

BY

IMMACULATE ABISACKI LIKUYI

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DECLARATION

Declaration by the student

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IMMACULATE ABISACKI LIKUYI SIGN:……………… DATE:………………

SASS/PGG/03/13

Declaration by Supervisors

This thesis has been submitted for examination with our approval as university supervisors.

…………………………………………. Date:…………………………….

Prof. Omondi Paul

Department of Geography

Moi University

…………………………………………. Date:…………………………….

Dr. Okaka Fredrick

Department of Geography

Moi University

ABSTRACT

Floods are the most common and widely distributed natural hazards to life and property worldwide. In Kenya, floods are often declared national hazards. Nzoia River flowing through Budalangi Sub-County in Western Kenya, causes floods to this region annually threatening economic, physical, social and psychological survival to the inhabitants in the Basin. The study set up to undertake a flood risk mapping and assessment within Budalangi region and identify those factors that motivate the affected community to continue living in the flood risk zones. The specific objectives of the study were to map flood risk and safe zones within Budalangi, map land use land cover from Landsat satellite image of Budalangi sub-county, determine the land use elements at risk due to flooding, and to analyze the socio-economic factors that retain residence at flood risk areas. A sample of 162 households were systematically interviewed out of 15,245 households. The information obtained complimented secondary data obtained from shuttle radar topography mission (SRTM). The study applied GIS and remote sensing (RS) in the assessment of flood risks in the area. Mapping of land use land cover of the sub-county was done through the use of 2016 Landsat 8 image. Elevation analysis was done using void filled 2013 SRTM image. This analysis aided in delineating all features at risk. There were 61.1% female respondents, while 38.9% were male. Geographic positioning system (GPS) coordinates were pegged on sample locations as well as other elements that required elevation verification. Flood stage scenarios were hypothesized below and above the actual flood stage to determine locations for evacuation in case of various magnitudes of flooding. The features at risk were also evaluated by using existing land use land cover and an overlay analysis taken to determine the areas and land use at risk. The study found that 3.5km^2 of settlement was at a greater risk while 12.5km^2 of farmland were in danger of flooding. Further, the study found that 36% of the entire land cover was under farmland and 9% of total land cover was under aquatic-riverine vegetation, majorly in the shores of Lake Victoria and along River Nzoia. The study categorized the flood zones as high flood risk areas, moderate flood risk areas and low flood risk areas. The study further identified various regions within the sub-county which the affected people can be relocated to, and it was established that Budalangi High School, Bukangasi, Musokoto village, West Bunyala Location to East of Mundere has 90% safe zones. The study concluded that farmland was at a greater risk affecting 19% or 12.5km^2 of farmland and 3.5km^2 of buildup areas. Societal factors such as land acquisition, fertility and food security were found to be the main reasons why the community still strives to occupy this territory. The study recommends that settlements below 1143m ASL should be relocated to high ground areas such as Bukangasi, Musokoto and Budalangi High school, which are safe from floods.

DEDICATION

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ACRONYMS AND ABBREVIATIONS

ADCL- Appropriate Development Consultants Limited

DEM - Digital Elevation Model

FAO- Food and Agriculture Organization

GIS- Geographic Information Systems

GoK- Government of Kenya

GPS- Global Positioning Systems

GLCF- Global Land Cover Facility

IPCC- Inter-Governmental Panel on Climate Change

ITCZ- Inter-Tropical Convergence Zone

LULC - Land Use and Land Cover

M.A.S.L- Meters above Sea Level

NDVI -Normalized Difference Vegetation Index

UNEP- United Nations Environment Programme

UN/ISDR- United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction

RS - Remote Sensing

SPSS- Statistical Package for Social Sciences

SRTM - Shuttle Radar Topography Mission

SSA - Sub-Saharan Africa

OPERATIONAL DEFINITION OF TERMS

Assessment of risk refers to the identification of potential hazards, such as floods, land degradation, water contamination, poor land use, and overcrowding among others using well established procedures that include the collection and analysis of data.

Capacity: A combination of all the strengths and resources within a community that can reduce the level of risk, or the effects of a disaster.

Flood mitigation refers to measures adopted to reduce damages to life and property by floods.

Floods refer to a temporary rise of the water level in a river or lake or along a sea coast, resulting in its spilling over and out of its natural or artificial confines onto land that is normally dry.

Flood risk refers to the probability that a high flow event of a given magnitude occurs which results in consequences which span environmental, economic and social losses caused by that event.

Geographic Information System is a system of integrated computer based tools for end to end processing (capture, storage, retrieval, analysis, display) of data using location on the earth's surface for interrelation in support of operations management decision making and science.

Land cover refers to the present state of the land and carrying capacity in its pristine state (e.g. grassland, desert). The land cover is defined by the attributes of the earth's land surface and immediate subsurface, including biota, soil, topography, surface and groundwater, and human structures.

Land use refers to the way the land is being used (e.g. residential, agricultural, mining) and the condition the land is in.

Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them.

Resilience refers to the ability of the system to recover from floods after disturbances so as to still retain essentially the same function, structures, identity and feedbacks.

Risk: The probability of harmful consequences resulting from interactions between natural or human induced hazards and vulnerable conditions. Risk = Hazards x Vulnerability / Capacity.

Risk analysis is a process of determining the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability/capacity that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend.

Vulnerability is the potential to suffer harm or loss, related to the capacity to anticipate a hazard, cope with it, resist it and recover from its impact. It's determined by physical, environmental, social, economic, political, cultural and institutional factors.

Mapping is the graphical representation of a procedure, process, structure, or system that depicts arrangement of and relationships among its different components.

CHAPTER ONE: INTRODUCTION TO THE STUDY

1.1 Background information

A flood is a hydrological event characterized by high discharges and water levels that can lead to inundation of land adjacent to streams, rivers, lakes, wetlands and other water bodies, (Mutiso, 2011). Floods are mainly caused by prolonged rainfall, however, there are other natural and man-induced causes such as failure of dams. They can also be caused by receding glaciers which when they melt, release enormous amounts of water stored in them at once, (Githui, Bauwens, & Mutua, 2007). Flooding is assumed to be a natural phenomenon (an act of God). However, some authors (Barredo,J 2009, 2006; Jain, Singh, Jain & Lohani, 2005) argue that floods are closely linked to anthropogenic activities within the catchment. Whatever the argument, floods damage the lives, natural resources and environment and also cause loss of economy and health.

Floods stand out to be one of the most frequent and devastating natural disasters around the world (Sanyal and Lu, 2004; Jonkman, & Kelman (2005), between 2000 and 2008 it is estimated that it affected an average of 99 million people per year World Health Organization (WHO, 2010). Jonkman (2005), states that floods alone killed 100,000 persons and affected 1.4 billion people in the last decade of the 20th century. During floods, a lot of livestock, property and human lives are lost and infrastructure is damaged. An assessment of annual cost of damages in the 2002/2003 floods was in the order of US$ 800,000 (Githui, F *et al.*, 2009).

United Nations Environmental Programme [UNEP] (2002), asserts that the major environmental disasters in Africa are recurrent droughts and floods. The impacts of these two are devastating to African countries since most of the African countries do not have real-time forecasting technology or resources for post-disaster rehabilitation. Most flooding in Africa, have been reported on rivers Limpopo, Nile, Senegal among others. In Egypt, the coastal area of the Nile Delta has been experiencing significant land use/cover change due to the control of the River Nile flooding regime and the extensive population growth (El-Asmar, H. M., & Hereher, M. E. 2011). Limpopo River experiences extreme precipitation and flood events regularly, this is often associated with cyclonic systems, (Asante, Macuacua, Artan, Lietzow, & Verdin, 2007). In 1999, Senegal River and its tributaries had higher river discharges due to higher precipitation rates. This resulted into larger inundations of the river valley and delta than it was seen during the previous 30 years, (Dia, Kouame, Rudant, & Wade, 2006).

In Kenya, most floods occur immediately after droughts (Huho and Kosonei, 2014). The main rivers in Kenya associated with floods are Nyando, Tana and Nzoia Rivers. The lower course of Nyando River, geographically referred to as Kano Plains, experiences floods that cover approximately 50% of the Nyando Sub-County (Ahmed, 2009). The Tana River also floods along the downstream areas along the river with flood waters originating from Aberdares and Mt Kenya catchments. Nzoia River floods the Budalangi plains with the flood waters arising from Cherangani hills and Mt Elgon (Nyakundi *et al.,* 2010).

According to study and reports by Government of Kenya, GoK, (2009) in the last two decades, major floods in Kenya have occurred in 1997-98, 2002, 2003, 2006, 2008, 2010, 2012 and 2015. The 1997-98 and 2003 floods were declared as national disasters by the Kenyan Government. It further states that the recent flood cases in Kenya include the ones that occurred during the first quarter of 2010 which claimed the lives of 73 people and 1,864 livestock countrywide. Over 3,375 households were displaced affecting 14,585 people. In addition, at least 16 bridges were destroyed in Rift Valley region. Flash floods that occurred in 2012 killed 84 people while displacing about 30,000 by June. The total number of people affected was over 280,000 (GoK, 2012).

Severe flood and drought disasters in Kenya cause major disturbances, destroying property and resulting in food insecurity and even loss of lives. The Kenya government recognized that anthropogenic factors like forest degradation and poor land use practices that disrupt watershed areas, drainage basins and flood plains often exacerbate the impact of floods. In some cases, floods have occurred in the river basins even with normal rains because of excess surface water runoff occasioned by deforestation and land degradation upstream (GoK, 2009a).

In Budalangi Sub County, the flooding of Nzoia River in 2010 left 2,633 people living as refugees in makeshift shelters. About 3,011 homes in all the five locations in the sub-county were submerged in flood waters (Dulo, S *et al.,* 2008). Among the agro-economic impacts of Budalangi floods is the decline in agricultural production. Serious food insecurity problems and high poverty levels are evident as a result of floods (Mutiso, 2011, RoK, 2004 and Okelloh *et al.,* 2010). However, in spite of the annual displacement and property damages from flooding, it has been noted that the affected communities relocate back to the flood zones immediately after floods subside, which begs the question, what motivates the residents to return despite the danger and losses accrued from floods over the seasons.

Some studies have analyzed the quality of the SRTM data in general, (Sun *et al.,* 2003; Smith and Sandwell, 2003; Kocak *et al.,* 2005). Ludwig and Schneider (2006) assessed the general quality of the SRTM data to evaluate their potential for hydrologic modeling in Southern Germany. They reached the conclusion that although SRTM data partially show low accuracy in mountainous terrain primarily due to radar shadow effects, the overall quality of the data sets is sufficient for hydrologic model applications in mesoscale areas. Onywere *et al.,* (2007), used remote sensing and Geographical Information Systems analysis combined with chemical and physical water analysis in the Lake Victoria watershed successfully, in examining the impact of land use activities on vegetation cover and water quality.

It is prudently clear therefore that the Budalangi floods pose major challenges to the riparian communities as well as to the Kenya Government. There is need for urgent solution to the problem of flooding if development has to take place within the sub-county (Mutiso, 2011). This study therefore sought to identify flood risk areas using GIS and RS techniques so as to help reduce the economic loss of property and lives in Budalangi sub-county when floods strike. This is different from what Balica 2013 did, as he did a comparative study using a parametric approach that is Flood Vulnerability Index, FVI and a deterministic approach which has a better science base. Further this study conducted a socio-economic assessment to ascertain the motives behind inhabitants continued settling and running their economic activities within the flood-risk areas.

1.2 Problem statement

In Kenya, floods continue to disrupt social life, destroy property and result in loss of lives, Ministry of Water and Irrigation [MWI], (2009). Fatalities due to floods constitute about 60% of disaster victims in Kenya (UNEP, GoK, 2009). In addition, floods have devastating impacts and pose risks to agricultural and industrial production, manufacturing, infrastructure, tourism and public health (Mogaka *et al.,* (2006); Mango *et al.*, (2007). Year in and year out, floods come in varying magnitudes posing risks to property and facilities, even those that were seemingly previously more secure. Hardly a year goes by without reported cases of damage to infrastructure, displacement of communities and loss of lives due to floods.

Future rainfall projections for Kenya up to the year 2030 broadly indicate that there will be increases in annual rainfall, with highest amounts expected in western parts of Kenya around Mount Elgon, Elgeyo Escarpment and Cherangany Hills (Mango *et al.*, 2007; MWI, 2009). These regions form a greater part of river Nzoia catchment which drains through the Budalangi plains. This is anticipated to lead to heavy rainfall that will culminate into heavy floods and increase the flood risk due to high runoff. As a result, thousands of people living in the lowlands may be forced to move to higher grounds and adopt various coping measures to survive (MWI, 2009).

During the floods of 2003 in Budalangi lowlands, floodwaters breached the southern dyke and displaced about 25,000 people. Some 10,000 people relocated to the District Officer's camp (Onywere *et al.*, 2011). Opondo (2013), on the report by Budalangi District Agriculture Office about flood impacts on agriculture in the year 2008, reported that flood damage occurred when high volume of water resulted in River Nzoia overflowing and breached on both sides of the river at four different points on the morning of Monday 10th November, 2008. The floods displaced about 3500 households (about 21,000 people) whose homes and farms were submerged and crops swept away. The affected area was estimated at 4152 acres of farmland with a total loss of over Ksh. 45 Million. The flooding of Nzoia River in 2010 left 2,633 people living as refugees in makeshift shelters. About 3,011 homes in all the five locations in the sub-county were submerged in flood waters (Mutiso, 2011, RoK, 2004 and Okelloh *et al.*, 2010). In December 2011, River Nzoia broke its dykes and flooded the

Budalangi flood plain, leaving massive destruction in its wake. Crops were washed away, livestock drowned, and houses and property were destroyed. There was an outbreak of water-borne diseases such as cholera, bilharzia and malaria (Opondo, 2013). The losses also included loss of human lives, washing away of graves and burial sites, trauma associated with drowning of family members and flood-related diseases (Otiende, 2009).

Budalangi is characterized by high poverty levels, rapid population growth, and increased pressure on land and water resources, limited livelihood opportunities, and low educational levels, (Opondo, 2013). These characteristics constrain their capacity to cope and adapt in the face of extreme weather events and slow-onset climatic changes. They make people in the Budalangi plains even more vulnerable and undermine sustainable development. In addition, productive agricultural land is often inundated leading to total destruction of crops and destruction of property and assets both of which result in widespread food insecurity in the areas directly affected and those that produce food consumed in other parts of the country. Flood waters have also been noted to lead to post harvest losses, that is, destruction of stored food and displacement of farming communities (Pere and Ogallo, 2006; Budalangi County Report, 2008; Otiende, 2009; Dulo *et al.,* 2010). Increased pressure on land due to population growth has driven encroachment into wetlands and the floodplain areas thereby exposing local communities to flood risk (Albinus *et al.,* 2008; Onywere *et al.,* 2011).

Some facilities like schools, health service centres and shopping centres are often inundated during floods due to lack of consideration of flood risk by planners due to project implementation. There is therefore a need to analyze the flood risk areas so as to help reduce the impacts of floods on human economic structures and fabrics.

Omondi (2008), suggests that the areas prone to flood disasters should be properly defined and mapped. Flood mapping is of greater importance in identifying areas that are partially and fully immersed by water when rivers break its banks, this gives a way ahead of evacuation routes, safe places for crop planting, building of granaries and houses, designated dyke construction sites and safe refuge places. Therefore, despite the fact that various studies have been done on the issue of frequent flooding in Budalangi, no study known to the researcher has been done on flood risk mapping and assessment using GIS and DEM in relation to flood peak stage in Budalangi Sub County in Busia County, hence a knowledge gap. It has also been perplexing that despite the frequent displacement and loss of properties, the affected communities continue to go back to the flood prone areas cognizant of the dangers, which calls for the need to find out the underlying factors that motivate the local community to continue occupying these flood prone areas. It is these gaps that the researcher sought to fill.

1.3 Objectives

The general objective of this study was to undertake a flood risk mapping and assessment within Budalangi Sub-County

The specific objectives are:

1. To map flood risk and safe zones within Budalangi Sub-county using SRTM data.
2. To map land use land cover from Landsat satellite image of Budalangi sub-county.
3. To examine the elements at risk from both land use/cover and flood risk maps.

4. To analyze the socio-economic factors that motivate those within the flood risk zones to continue occupying the areas.

1.4 Research questions

1. Which areas are at highest risk of flooding within Budalangi flood plains?
2. Which areas are safe from flooding within Budalangi flood plains?
3. What elements are at highest risk of destruction upon flooding?
4. Why do inhabitants at risk of flooding continue to settle and carry on with activities within the flood plain despite the looming dangers?

1.5 Justification of the study

Although extensive studies on floods have been done in various parts of the world, a large proportion of these studies have been based on social, psychological preparedness and quantification of loss. A few of the studies on selected river have considered risk mapping. It was important to consider and map the risk elements within the Budalangi flood plain so that during rescue, there would be adequate information of what is more vulnerable than the other. Further, during relocation, there is need for information on the safe area that can accommodate the evacuees.

For purposes of Busia county government planning for developmental projects such as schools, hospitals, roads, etc., there is need for information on the safe sites within the county for such projects at various flood magnitudes. Further, there is need to construct rescue facilities within safe zones so as to reduce the double tragedy of the rescue team seeking for rescue services for their facilities.

Within many flood plains world over, farming is the main economic activity. This is because flood zones carry within them fertile soils and farmers would utilize the same enhancing bumper harvests. This has not been the case with many flood zones in the world because of lack of adequate information on flood risk zonation within the flood zones. This study has provided such information so that people within the floodplain can cascade their daily activities based on the magnitude of the risk associated with the region so as to reduce on the losses upon flooding. The study proposes to mitigate the same by providing safe (free-from-floods) locations.

Flood zones globally face a risk of property damage and the lack of appropriate planning on flooding has costed a lot of damages to property. According to Brinke (2010), the flood prevention methods like construction of dykes has been happening for long as a measure to curbing floods. Planning is key to flooding and contingency planning for extreme flood disasters have been seen to be a proper and effective method of flood planning. Clarke (1999), talks about fantasy documents when discussing plans in which organizations and experts claim to control disasters that cannot be controlled (such as a major oil spill) or where the knowledge and experience necessary to know what would make for a realistic plan are unavailable (such as recovery after a nuclear war). In his view, 'planning for these catastrophes is symbolical, the plans representing something other than a real capability to imagine the future and prepare for it'. Even though fantasy documents may not teach us what happens during a worst case and how well we are prepared to deal with it, 'we can use these worst case scenarios to become smarter about how the world works, and what could happen if the world breaks' (Clarke, 2006). Budalangi region is a flood risk zone. This study has provided much information on the factors that make people stay in flood risk areas despite experiencing the risk repeatedly. This will help to inform policy makers on developing guidelines which will help the entire community in making useful choices regarding disasters.

1.6 Scope, limitation and delimitation of the study

This study was restricted to analyses of risk zones within Budalangi sub-county. Safe zones were evaluated within the sub-county. The most currently available Landsat image to the researcher was utilized to evaluate land use. The study used LANDSAT imagery as it provided just the necessary detail required (high-quality, moderate resolution).

Terrain data was analyzed from SRTM to determine the areas that were at high risk of flooding and to find out areas within the flood plain that were safe in carrying out economic activities. SRTM was supplemented with GPS and contour data from topographic maps. Socio economic analysis was limited to the flood zones of Budalangi sub-county.

The study did not involve any rainfall amounts and measurements within the catchment of the Nzoia River since flood causes is a blend of complex phenomena that will constitute a whole research agenda.

1.7 The study area

1.7.1 Location and size

The research was conducted within Budalangi Sub-County within which the Nzoia River Basin lies. The sub-county lies between latitudes 1º 30'N and 0º 05'S and longitudes 34º 00' and 35º 45'E. This is the largest river basin in Kenya's Lake Victoria basin. It has its sources in the Forested highlands (the Elgeyo escarpment, Mt. Elgon and Cherangani Hills). The River Nzoia discharges into Lake Victoria just a short distance north of the Yala Swamp in Bunyala, Budalangi Sub-County, and Busia County. The Nzoia River originates from Cherangani Hills and on Mt. Elgon at an elevation of 4320 m.a.s.l (Ssegane, 2007), and at a mean elevation of 2300 m.a.s.l and drains into Lake Victoria at an altitude of 1000 m.a.s.l. It runs approximately South-West and measures about 334 km with a catchment area of about 12,900 km^2 (NRBMI, 2011) with a heavy forest cover in the upper parts of the catchment and low trees and bushes in the lower reaches, with a mean annual discharge of 1777 x 10^6 m^3/year. It lies within the South-Eastern part of Mt Elgon and the Western slopes of the Cherangani Hills. Budalangi floodplain is situated at the lower reaches of Nzoia River. Rivers Nzoia and Yala traverse the Sub County periodically causing floods in lower areas as they enter Lake Victoria.

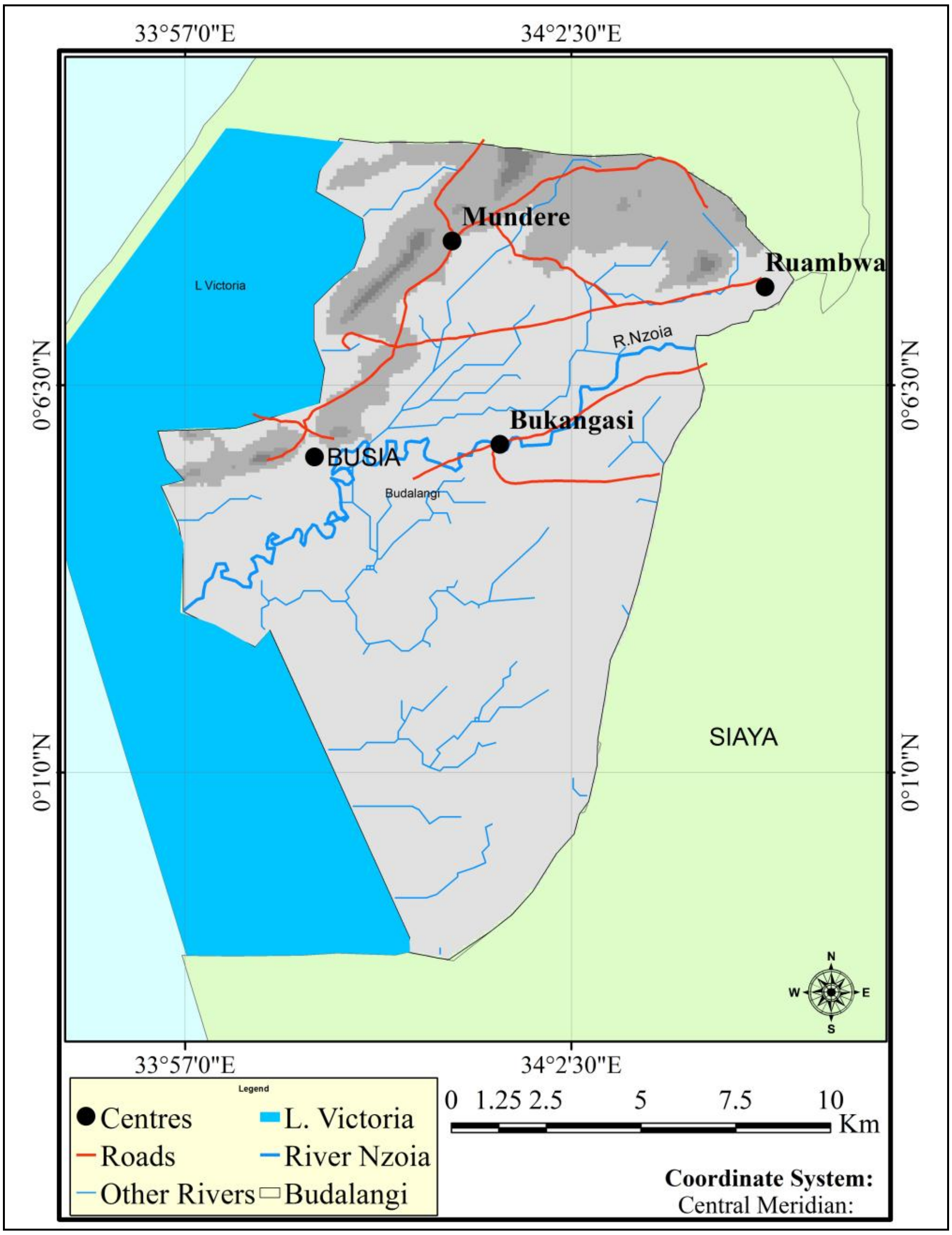

Figure 1.1: Map of study area.(source author 2018)

1.8 Physical environment

1.8.1Topography

The floodplain falls on the sediment plain of Nzoia Catchment within the altitude range of 1100 to 1350m above mean sea level. The floodplain topography is fairly flat to very gently undulating with gradients of less than 2% (Mutiso, 2011). The area has a flat topography through which River Nzoia meanders, often spilling floodwaters over its banks on to large areas of the flood plain. There are many settlements near the dykes along the river, and in some locations there is encroachment into flood plains for agriculture, livestock keeping and fishing (GoK, 2009a; Onywere, *et al.*, 2011).

1.8.2 Hydrology and climate

The mean monthly rainfall trend represents two maxima and minima over the year. The first and second maxima occur from April to May and July to November respectively. The minimum and maximum mean monthly rainfall is 20 mm and 200mm respectively. The mean annual rainfall varies between 1,000 to 1,500 mm. The upper catchment is characterized as a high rainfall zone with a mean annual rainfall varying between 1,500 to 1,700 mm (Mutiso, 2011).

The length of the main stream is about 252 km with a fall of about 1,200 m giving a 0.5% slope in the upper reaches, which reduces to 0.04% in the lower reaches over the last 30 km. Over this stretch the river meanders and causes deposition of silt due to the low gradient. The sediment accumulates and reduces the discharge capacity of the river channel so that it over flows its banks causing flooding in the lower reaches of the basin. The highest river discharges occur between May and September while the lowest river discharges occur between January and March (Mutiso, 2011)

1.8.3 Rainfall

The Budalangi area receives an average rainfall of about 1100mm, but may at times get to as little as 800mm. The high flows from the upper catchment results to floods when the river banks burst (Nyadawa *et al.*, 2010).

1.8.4 Geology

Most of the physical characteristics of a basin are influenced by geology. Geological factors also largely determine the storage time during which water is held between the rainfall and the eventual runoff as stream flow. Nzoia River Basin has the same geology as the main Lake Victoria Basin. Geological formations in the basin vary from recent quaternary sediments to old rocks of Archean age. The most common formation is tertiary volcanic rocks occurring in most of the eastern parts and extends to parts of the lakeshore area. The Bukoban system of Precambrian age covers Kisii area and the surrounding areas including the Nzoia River basin (Mutiso, 2011).

Rocks of Archean age of the Kavirondo and Nyanzian system are also common in the basin. The structural framework of rock material determines the rate at which water moves through the rock. It also determines the direction of movement of water and therefore mixing of waters from different aquifers (Opere, 1998).

1.8.5 Soils

The soils type in the floodplain is dominantly black cotton soils (vertisols) with heavy alluvial deposition within the river channel while other areas have coarse textured sand silt mixtures. The soils of the floodplain in the lower reaches of the Nzoia River are all of alluvial type. The river meanders in the floodplain depositing silt during seasonal floods. Pockets of shallow murram soils (course textured) are also evident (NWCPC, 2008). In some places, saline soils exist, the Upper Nzoia basin contains extensive seasonal swamp areas in the high and medium rainfall zones that are mainly utilized for grazing due to poor drainage.

Runoff largely depends on rainfall intensity while soil characteristics play an important role in determining flood peaks. The more impervious soils like the black cotton soils produce high surface runoff (Opere, 1998).

1.9 Human environment

1.9.1 Population

The entire population of the Sub County is estimated to be 64,000 people, (Kenya National Bureau of Statistics, 2010) and the most important economic activities are agriculture and fishing, (Onywere, *et al.*, 2011). Almost 90% of the population lives in rural settlements and 70% of the total population lives below the poverty line. Budalangi constituency is among the poorest constituencies in Kenya. (CBS, 2005; KNBS, 2010).

1.9.2 Settlement

The density of human settlements is pronounced with considerable economic activity in the form of agriculture and livestock farming (Nyadawa *et al.*, 2010). The population density of the area is 66,723 (Ranked 202 of 290 Constituencies in Kenya) occupying an area of 188.3 km putting the density of its population at 354 persons per square kilometer with an average Household size of 4.38 persons per household (Onywere, 2011). The farms are privately owned and on average 1 – 3 hectares. The area has a high population density, most households own small parcels of land for crop subsistence farming (crops and livestock), (Opondo, 2013).

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter comprises of literature on floods as a natural disaster, flooding in Kenya, previous researches in Budalangi, land use and land cover, risk, literature on geographic information system, flood risk assessment, digital elevation model, socio-economic activities, the conceptual framework and the knowledge gap.

2.2 Floods as a natural disaster

Floods are a result of overflow in river banks and can cause enormous damage to life and property including crops and infrastructure. These are common phenomena and are costly natural disasters. Floods are short-lived events that can happen suddenly, sometimes with little or no warning (Paron, 2013). They are usually caused by intense storms that produce more run-off than an area can infiltrate and store or a stream can carry within its normal channel. Rivers can also flood when dams fail or landslides temporarily block a channel (Opere, 2013). Flood risk refers to the probability that a high flow event of a given magnitude occurs which results in consequences which span environmental, economic and social losses caused by that event (Balica *et al.*, 2013).

Floods are one of the most common and widely distributed natural risks to life and property. Damage caused by floods on a global scale has been significant in recent decades (Jonkman and Vrijling, 2008). In 2011, floods were reported to be the third most common disaster, after earthquake and tsunami, with 5202 deaths, and affecting millions of people (CRED, 2012). River, coastal and flash floods can claim human lives, destroy properties, damage economies, make fertile land unusable and damage the environment (Balica *et al.*, 2013). This study therefore aimed at looking at the elements at risk of flooding and established the reasons as to why the residents of Budalangi are adamant of moving despite the frequent floods that lead to loss of lives and destruction of properties.

Increase in magnitude and frequency of the floods have been observed in Poland, Japan, Germany and Kenya (Pinter, 2010). There have been remarkable floods in the last half of the twentieth century (Ngaira, 1999). The period between 1980 and 1985 experienced more than 160 major floods in Asia causing damage estimated at US$ 2 billion (Houghton, 1997). In South America, North America, south Asia and Africa floods and mudslides make regular news. In North America, for example, floods and mudslides are the leading cause of deaths from natural disasters (Huho, 2014). The number of deaths associated with floods increased from 5.2 million per year in 1960s to 15.4 million per year in 1970s in South America. In India, the number of lives lost was fourteen times greater in 1980s compared to 1950s (Clarke, 1991; Cohen and Miller, 2001). In economic terms, floods are the most expensive natural disaster. In Australia, for example, direct costs associated with floods averaged at US $370 million per year between 1967 and 2005 (Chief scientist, 2013)

The increased risk of floods due to climate change and increased climate variability such as El Niño in poor developing countries has been recognized (IPCC, 2007; IGAD and ICPAC, 2007). There have always been floods which have occasioned devastating consequences worldwide. The current scenario is aggravated by climate change and human activities. Moreover, there is growing awareness of the effect of climate change on the frequency of floods especially in developing countries. A number of studies conducted by the Intergovernmental Panel on Climate Change (IPCC) predict future increases in flooding due to escalating storm activity and overall rise in amounts of precipitation (IPCC, 2007).

Climatic changes include rising temperatures and highly variable rainfall patterns, which result in increased frequency of extreme weather events such as floods and droughts. Rainfall variability has been observed in sub-Saharan Africa (SSA) with decreases recorded in the Sahel region and increases in the East and Central African region. Consequently climate-related disasters such as floods and droughts have doubled in these regions within the last quarter century. Mozambique, Malawi, Kenya, Madagascar and Ethiopia are examples of SSA countries likely to experience unexpected adverse weather patterns (World Bank, 2009).

The climate change-human-induced activity nexus is a complex phenomenon difficult to disentangle since human activities destroy the mechanisms through which nature minimizes the destructive effects of natural disasters such as floods. These have increased flood peaks and reduced flood-carrying capacity of rivers because of excessive siltation of riverbeds and river mouths with many adverse impacts.

The study recognized that flood is a major disaster, ranked third after earthquakes and Tsunami (CRED, 2012). There is need therefore to determine key measures on how floods can be tackled especially in developing countries which (IPCC, 2007; IGAD and ICPAC, 2007) notes that these are the worst affected Nations when floods occur. The key example is country like Haiti and the Dominican Republic on the Hurricane Matthew scenario where the two countries were hit by an earthquake but Haiti suffered the most, there is need therefore to provide coping measure by evaluating elements at risk and determining safe zones to avert the flood dangers.

2.3 Flooding in Kenya

In Kenya, hazards caused by river floods are a common phenomenon in most parts of the country (Odingo and Kaudia, 2009). Areas of Budalangi in Western Province are prone to floods. Floods in Budalangi Sub County of Busia County are caused by intense storms upstream (Cherangani Hills and Mt. Elgon) of the catchments that produce more runoff than the catchment can store or the main Nzoia River can carry within its normal channel. These floods occur frequently during long-rain (March to May) and the short-rain seasons (October to December) and disrupt normal activities in the flood plains. The impacts include mass displacement of the communities and their domestic animals, loss of life and property. Floods also cause destruction to infrastructure, loss of land and biodiversity and displacement of the people. According to MSSP (2009), weak institutional linkages among flood mitigation stakeholders, policy makers, implementers, donors and humanitarian service providers amongst others, have hampered effective and efficient transmission of flood early warning information to the affected people in Budalangi. Currently, emergency services and early warning systems are inconsistently coordinated by the government thus, creating confusion among various stakeholders (MSSP, 2009). This has led to waste of valuable time and resources, duplication of roles and apathy among the affected people. As a result, floods have continued to wreak havoc in the area exacerbating poverty levels as they destroy crops, businesses, infrastructure and other forms of livelihoods (Table 2.1). The problem causes increased waterborne diseases such as typhoid and malaria, increased shortage of food, limited sanitation and low school attendance (IFRCCS, 2002). Despite all these factors that cause regular incidences of flooding in the area, people of Budalangi have continued to occupy the flood prone areas, thus endangering their livelihoods.

Table 2.1: Estimated impact of flooding in Kenya and East Africa (Source: RCMRD)

	Kenya 2006	**East Africa 2006**
Property loss ($ US)	250 million	400 million
Displaced persons	300,000	850,000
People needing emergency relief service	250,000	700,000
Deaths	260	1,000

Future rainfall projections for Kenya up to the year 2030 broadly indicate that there will be increases in annual rainfall, with highest amounts expected in western parts of Kenya around Mount Elgon, Elgeyo Escarpment and Cherangani Hills. If these projections are accurate, there are likely to be far-reaching effects on the intensity and frequency of floods in the region (Mango *et al.*, 2007; MWI, 2009). As a result of increased frequency and intensity of floods, thousands of people living in the lowlands are forced to move to higher ground and adopt various coping measures to survive (MWI, 2009). While these coping measures may be successful in the short term, they often have severe implications for longer-term livelihood sustainability. Many of the measures people adopt allow them to survive the impact of floods but not to recover from it. The resulting loss and damage and inadequacy of coping mechanisms occasioned by floods therefore pull people into an ever-more vicious cycle of poverty. Mapping of land use and land cover of the area will help the residents to get to know the elements and regions that are at most risk. This will eventually guide the residents on how to avoid serious damages resulting from floods.

UNEP and GoK (2009) reported that fatalities due to floods constitute about 60% of disaster victims in Kenya. In addition, floods have devastating impacts on agricultural and industrial production, manufacturing, infrastructure, tourism and public health (Mogaka *et al.*, 2006; Mango *et al.*, 2007).

2.4 Flooding in Kenya and its socioeconomic impact

Floods and droughts, associated with extreme climate events, have very devastating effects on almost all socioeconomic activities and are very common in many parts of Africa. Flooding in its most immediate form can inundate farms and villages and disrupt transportation networks, ultimately affecting food security and market distribution systems (Opere, 2013).

In Kenya, the hazards and impacts of floods were demonstrated by the 1997/1998 El Niño episodes. These floods led to severe loss of life and property, destruction of infrastructure, disruption of the communication networks and large losses to the economy. They were also associated with land degradation (soil erosion), silting of hydropower dams and destruction of power lines (Opere, 2013). Despite all these destruction and losses caused by the floods, the residents of Budalangi still continue to reside in the same place hence risking their lives.

Flood hazards resulting from too much rainfall have resulted into disasters in Kenya. Examples are areas of Kano Plains in Kisumu County, the lower parts of the Tana River and Budalangi in Busia County that are susceptible to floods. Floods have adverse effects on health and health service in terms of disease outbreaks and the capability to reach people when roads are not passable. The congestion in the camps also poses a big health challenge in terms of communicable diseases. Flooding is associated with diseases such as malaria, typhoid and bilharzia (schistosomiasis). Interference with culture as seen in congestion of households with children of up to 15 years hurdled with their parents in the camping structures also contributes to social and health problems. Floods also enhance environmental degradation and destruction of homesteads. It also destroys the normal economic production, distribution of goods and food harvests.

In many low-lying areas around the mouths of the rivers and natural swamps, the inundation lasts for weeks, leading to total loss of crops. Poverty, lack of education and poor rural infrastructure, they are the most vulnerable to floods and post-flood consequences. The floods severely limit and hamper the developmental process, further increasing the vulnerability of the rural society and thereby perpetuating and increasing the incidence of poverty. Stagnant floodwater also causes vector-borne diseases, which result in high incidence of morbidity with consequent loss of alternative employment opportunities. An exception is made by farmers whose cropping practice relies on flood-recession agriculture like in the low lands of the Budalangi and in other countries: for these communities the flooding is beneficial to their agricultural production and thus to their economy.

In most cases, though people from inundated areas move to makeshift relief camps where they cluster together. Such makeshift homes soon become slums creating social problems and unhygienic conditions, which are conducive for the spread of contagious diseases and sexually transmitted diseases. Often, women and young girls are the worst sufferers, (Opere, 2013).

The lower reaches of River Nzoia are flat lands with low gradients. All the six locations in Budalangi Division are perennially affected by flooding. These are, namely, Bunyala East, West, South, North and Central and Khajula location. Traditionally, the people have settled in the flood plain and this has meant that the people are directly affected by the perennial flooding. The April 2003 floods displaced 4000 families or about 24,000 people, covering an area of 60 km^2 with people moved to camps on higher areas and relying on food relief (Opere, 2013). This situation has risen after breaching of protection dykes that were constructed by the Ministry of Water from 1977 to 1984. The works involved construction of 32.8 km of earthen dykes 16.6 km in the southern side and 16.2 km on the northern side that required a replacement of 690,000 m^3 of soil. They were designed for 25-year flood protection of 750 m^3/s. Now the dykes are occasionally overgrown with vegetation, breached at 20 points and have outlived their life of 20 years. The budgetary maintenance requirements are therefore high and have been diminishing annually.

A report given to the government in 1992 after the assessment of the area proposed an irrigation scheme as the solution to the unending flood menace. The report said that a dam is needed to be constructed to trap the excess water that overflows the river. This would be followed by the construction of two canals, one in the northern riverbank measuring 40 km and the other on the southern side measuring 35 km, draining water onto the flat farms for irrigation. 'The project could cost about $20 million if implemented'. It is evident the present course of the river is highly unstable and could change from one moment to the next after a flood, if no protective works are provided.

The 2003 floods in Budalangi saw nearly 24,000 out of a population of 56,000 people displaced (source: IFRC, 2003). Scarcity of water sources and the contamination of pipes and bore wells aggravated an already acute problem. Fishing and farming are the major economic activities in Budalangi. Due to the floods and concentration in the camps, the economic activities are greatly disrupted.

In such areas, marginally productive land has been over-cropped and other unsustainable farming practices have been in use. This makes the farmers very vulnerable to natural variations such as lack of rain. The situation is aggravated by a number of other problems such as overpopulation. Inappropriate farming methods have created large tracts of degraded land where erosion has stripped away fertile land. As such, the small-scale farmers can no longer grow successfully certain crops and are forced to change their farming methods but lack the knowledge and resources to do so. As a result, they continue to grow the wrong crops in the wrong places causing even more damage and land degradation. This kind of farming leads to more and more poverty because the growing of crops on degraded land means that the yields are poor. This way the farmers make no money, which they could use to invest on their land for better yields. All these needs make the basin vulnerable to any hydrologic impacts of land use and climate changes.

Farming communities in the area are frequently displaced by flooding with devastating effects on agricultural production. Crop losses of over 50 percent are experienced approximately once every three years. This has serious implications on food security in the area (Mogaka *et al.*, 2006).

Flood impacts in Budalangi area manifested through the inundation of productive agricultural land often leading to total destruction of crops and destruction of property and assets both of which result in widespread food insecurity in the areas directly affected and those that produce food consumed in other parts of the country. Flood waters have also been noted to lead to post harvest losses, i.e., destruction of stored food and displacement of farming communities in Budalangi, Kano Plains and the lower Tana River Basin (Pere and Ogallo, 2006; Budalangi District Report, 2008; Otiende, 2009; Dulo *et al.*, 2010). In Budalangi District, the losses also include loss of human life, washing away of graves and burial sites, trauma associated with drowning of family members and flood-related diseases (Otiende, 2009). During the floods of 2003, floodwaters breached the southern dyke and displaced about 25,000 people. Some 10,000 people relocated to the District Officer's camp which necessitated emergency measures to control possible outbreaks of malaria, bilharzias, cholera and other water borne diseases (Onywere *et al.,* 2011).

The costs of flooding due to human displacement can be immense, and are mostly borne by the poor and vulnerable. This is especially true given that it is usually the very poor who are forced to settle in the flood-prone plains to eke out a living from crop cultivation, livestock keeping and fisheries (Otiende, 2009). In Budalangi, increased pressure on land due to population growth has driven encroachment into wetlands and the floodplain areas thereby exposing local communities to flood risk (Albinus *et al.,* 2008; Onywere *et al.,* 2011).

The disproportionate burden borne by women in regard to floods is attributed to their being among the most vulnerable groups in the communities. Women are hardly involved in decision-making processes and in aspects like flood risk reduction planning and implementation of activities (Otiende, 2009). This is worsened by the patriarchal system of the Manyala people (Onywere *et al.,* 2011). Authority to make decisions on matters that affect the community like flood risk management is always vested upon elders, often older men in the community who tend to have near-supreme authority and perpetuate their dominance by being the first port of call even for external agencies initiating interventions in the community (Ngenwi *et al.,* 2011). Despite these impacts the people of Budalangi still return to their risky settlements and hence the need for the study.

2.5 Related Studies in Budalangi

Balica, (2012) carried out a study in Budalangi, comparing the parametric and physically based modelling techniques for flood risk and vulnerability assessment. He identified the risk in flood-prone areas in order to support decisions for risk management, from high-level planning proposals to detailed design. He concluded that the parametric approach, here the Flood Vulnerability Index (FVI), is the only one which evaluates vulnerability to floods; although the deterministic approach has limited evaluation of vulnerability, it has a better science base. On the contrary, this study aims at mapping the areas at most risk, further establishing why the residents continue to occupy the flood prone areas despite regular incidences of flooding in the area. This study will therefore adopt a parametric analysis design where parameters that include social, economic and infrastructure will be evaluated to arrive at a probable cause of why the residents don't want to move from their zone.

Onywere *et al.,* (2011), conducted a study on the assessment of the challenges of settlement in Budalangi and Yala swamp area in Western Kenya using Landsat Satellite imagery. This study examined the impacts of land use activities in Budalangi and Yala Swamp area in Western Kenya. It assessed the land cover/use trend in the study area using Landsat image data and documented the status of encroachment into the wetland areas and therefore the level of their degradation. Using a participatory process, the interpreted Landsat land cover/use classes were assessed in the field to document how the existing sector policies, institutional and legislative frameworks have contributed to the current status. He emphasized the need to evolve an integrated watershed management plan for effective management of Budalangi and Yala Swamp area and the region in general. This study examined the impacts of land use activities in Budalangi and Yala Swamp area whereas my study is basically confined to Budalangi Sub county alone and it is mapping the current land use land cover within the region in order to identify the elements at risk and find out why the residents of the area have stayed put. This study involved a comparative study and looked at the trend over time which is not found in my study.

Onywere *et al.,* (2007), did a research involving two case studies illustrating the effects of intensified agriculture and the changing livelihood systems at the upper part of Middle Nzoia Catchment at Nzoia sugarcane growing area and the flood plain area of Nzoia River at Budalangi which were presented to show the potential of geo-information technology in assessing and monitoring land use changes and impacts. Whereas Onywere *et al.,* (2007), used a case study and did monitoring of land use changes, this study has used a cross-sectional survey and did not consider land use change over a scale of time but took land use/cover activities as at March, 2016 to determine floods prone areas and land uses at risk. Further, Onywere *et al.,* (2007), examined the impact of land use activities on vegetation cover and water quality based on remote sensing and Geographical Information Systems analysis combined with chemical and physical water analysis in the Lake Victoria watershed. The research did not determine any relationships between the existing land use, vegetation cover and water quality.

Omondi (2008) examined the land-use planning and zoning issues involved in natural hazards and disaster management, focusing on areas prone to flood disasters in Kenya. He argued that the loss due to disasters could be significantly reduced through appropriate land use planning and zoning including development control and building codes and standards. He suggested that the areas prone to flood disasters should be properly defined and mapped and land use development of high population should be discouraged in flood disaster-prone areas, especially in the rural areas. My study has been developed partially from this study since Omondi, 2008, suggests that areas prone to flooding as a disaster should be properly defined and mapped.

Omondi, Omuterema, and Musambayi (2008), assessed floods problem in Budalangi region, the level of vulnerability of the area, its people and property to flooding, the flood impacts and suggested strategies that can provide long-term flood mitigation and poverty alleviation in the region. In this relationship, the study will link the land uses at risk and the property damage that can be caused by floods and in return suggest on appropriate measures for flood risk zones and safe zones.

Githui, Mutua and Bauwens (2009), did an assessment of the past and potential future environmental changes and their impact on hydrology of Nzoia Catchment using the Soil and Water Assessment Tool (SWAT) model. Also, Githui *et al.,* (2009) has widely researched on climate changes from the past and future and how it impacts on the trends of floods in the entire river Nzoia catchment. While Githui *et al.,* (2009) focused on how flooding in Nzoia Basin has impacted on environment and hydrology, the current study is limited to those features that are at risk to flooding and the reasons as to why the residents don't want to move from the areas. While Githui, 2007 involved changes in land use and land cover, this study does not cover the scenario. Also, Githui has widely researched on climate changes from the past and future and how it impacts on the trends of floods in the entire river Nzoia catchment. This is not part of my research.

Sakataka and Namisiko (2014) looked at the effects of livelihood activities on wetlands in Upper Nzoia River Basin. The study used a combination of cross-cultural and cross-sectional, longitudinal survey to elicit information and data. My study is different from this study in terms of methodology. Ndiwa *et al.,* (2014) engaged the Ensemble Kalman Filter (EnKF) together with the Probability Distributed Moisture model (PDM) to forecast flood events over Nzoia sub-basin. This study involved use of EnKF and PDM which does not suffice in my study.

Kuria, (2014) explored the applicability and performance of flood forecasting models in the Nzoia River basin, Western Kenya, using two types of artificial neural network (ANNs), namely MLPANN-FF a feed forward multilayer perceptron (MLP) network and GA-ANN-FF a genetic algorithm optimized multilayer perceptron feed forward neural network model. He aimed at comparing the performance of these two models (MLP-ANN-FF and GA-ANN-FF) and recommended the most suitable for the problem. While Kuria (2014), looked at the applicability and performance of flood forecasting models in River Nzoia, my study focused on the flood risk assessment using GIS and RS. This study involved a comparative dimensional perspective which is different from my study in terms of methodology.

2.6 Land use and land cover

Land use is used to describe how human uses land, including actions that modify or convert land cover from one type to another. Examples include categories such as human settlements (e.g. urban and rural settlements), agriculture (irrigated and rain-fed fields), national parks, forest reserves, and transportation and other infrastructure. Land cover refers to the vegetative cover types and other surface cover that characterize a particular area. Examples include forest, savannah, desert, etc. Under such categories we can have more refined categories of specific plant communities' shrub-lands, mangroves and seasonally flooded grassland (Lambin *et al.*, 2001; Githui, 2009). Land use land cover mapping was done in order to identify the elements at risk.

2.7 Risk

Risk is an integral part of life. Indeed, the Chinese word for risk "weji-ji" combines the characters meaning "opportunity/chance" and "danger" to imply that uncertainty always involved some balance between profit and loss (Ologunorisa *et al.,* 2005). Since risk cannot be completely eliminated, the only option is to manage it. Risk assessment is the first step in risk management. Risk assessment according to Kates and Kasprson (Ologunorisa *et al.,* 2005) comprises of three distinct steps:

a) An identification of hazards likely to result in disasters, e.g. what hazards events may recur?
b) An estimation of the risks of such event, e.g. what is the possibility of such event?
c) An evaluation of the social consequences of the derived risk, e.g. what is the loss created by each event?

However, for sound risk management to occur, there should be a fourth (d) step which addresses the need to take post-audits of all risk assessment exercises. When risk analysis is undertaken, risk (P) is taken as some product of probability (P) and loss (L).

R = P x L …… (1)

Flood risk involves both the statistical probability of an event occurring and the scale of the potential consequences (Ologunorisa *et al.,* 2005). All development of land within the floodplain of a watercourse is at some risk of flooding, however, small. The degree of flood risk is calculated from historical data and expressed in terms of the expected frequency 10 year, 50 year or 100-year flood.

Flood risk is a function and a product of hazard and vulnerability (Ologunorisa, 2001). That is, Risk = Hazard x Vulnerability. A real flood risk level requires a certain level of hazard, and for the same location, a certain level of vulnerability. A situation of risk is due to the incompatibility between hazard and vulnerability levels on the same land plot. The United Nations Commission for Human Settlements (UNCHS –

HABITAT) (Ologunorisa *et al.,* 2005) has defined the three terms in the following way:

- Hazard: is the probability that in a given period in a given area, an extreme potentially damaging natural phenomena occurs that induce air, earth movements, which affect a given zone. The magnitude of the phenomenon, the probability of its occurrence and the extent of its impact can vary and, in some cases, be determined.
- Vulnerability – of any physical, structural or socio-economic element to a natural hazard is its probability of being damaged, destroyed or lost. Vulnerability is not static but must be considered as a dynamic process, integrating changes and developments that alter and affect the probability of loss and damage of all exposed elements.
- Risk – can be related directly to the concept of disaster, given that it includes the total losses and damages that can be suffered after a natural hazard: death and injured people, damage to property and interruption of activities. Risk implies a future potential condition, a function of the magnitude of the natural hazard and of the vulnerability of all the exposed elements in a determined moment.

Ologunorisa (2004) undertook an assessment of flood risk in the Niger Delta, Nigeria using a combination of a hydrological techniques based on some measurable physical characteristics of flooding, and social-economic techniques based on vulnerability factors. Some of the physical characteristics of flooding selected include depth of flooding (meters), duration of flood (hours/weeks), perceived frequency of flood occurrence, and relief or elevation (m) while the vulnerability factors selected include proximity to hazard source, land use or dominant economic activity and adequacy of flood alleviation schemes and perceived extent of flood damage. He derived rating scale for the nine parameters selected, and 18 settlements randomly selected across the three ecological zones in the region were rated on the basis of the parameters.

Three flood risk zones emerged from the analysis. These are the severe flood risk zones, moderate flood risk zones and low flood risk zones. Some strategies for mitigating the hazard of flooding in the region were identified. Ologunorisa *et al.,* 2005 undertook an estimation of flash flood potential for large areas in United States of America. A methodology for determining the potential for flash floods in small basins within large geographical area was presented. Geographical Information System (GIS) technology was used to assimilate digital spatial data, remotely sensed data, with physically-based hydrological – hydraulic models catchment response. The methodology used digital terrain elevation data, Digital River reach data, and the US Geological Survey land-use and land cover data to produce estimates of the effective rainfall volume of a certain duration required to produce flooding in small streams. This flood potential index is called threshold runoff. For operational application, soil water accounting models were used to yield estimates of effective precipitation over areas of 1000km. Maps of flash flood potential could then be constructed using remotely-sensed and on-site data.

Ologunorisa *et al.,* 2005 reported that in Thailand flood forecasts were prepared for the Huainan Chun catchment of Pa Sak Watershed, Phetchabun province, using a hydraulic model and a GIS. The objective was to test what extent the integration of a hydraulic model and a GIS can contribute to the quantitative assessment of effects of the upstream land use changes on downstream flood pattern. The Hec-1 hydraulic model and ILWIS (GIS) were used.

The result of the simulation were able to show the effect of the land use changes on flood levels downstream. The result of the study further showed that a hydraulic model like HEC-1 makes it possible to predict the effects of upstream land use changes on downstream level. GIS appeared to be an efficient tool for the preparation of part of the input data required by such a model but it was not possible to link the GIS and the HEC-1 directly. It could not be confirmed whether the use of a GIS would be an advantage when other hydraulic models are used.

Also in Netherlands, the GIS technique was applied to Meuse in the South of Netherlands after the flooding of December 1993. It was observed that the river flooding can have a severe impact on the society and to reduce the potential damage in the future, structural measures such as increasing the storage capacity inside or outside the river bed or improving dikes are essential. To support decision-making when choosing and evaluating adequate measures 'Defit hydraulic' developed a flood hazard model and in developing the model the GIS package known as Arc/info turned out to be a valuable tool in developing the model and this supported decision making. The model was successfully applied to calculate the impacts of potential strategies for the River Meuse in the South of the Netherlands. It is pertinent to note that while the potential of GIS as an environmental analysis technique is improving, complementing and occasionally displacing the traditional field survey technique in most developed countries and even in some developing countries, their use still remain largely un-demonstrated in many developing countries.

This study observed that the GIS techniques is the most recent and holds a lot of promises as it is capable of combining all the known techniques and parameters of predicting flood risk. The study concludes that the use of GIS technique should be encouraged in risk assessment of flooding as it is capable of integrating the geomorphological, hydrological, meteorological and socio-economic variables.

2.8 Flood risk assessment

Floods stand out to be the most frequent and devastating natural disaster around the world (Berz et al, 2001; ISDR, 2004; Sanyal and Lu, 2004), affecting an average of 99 million people per year between 2000 and 2008 (WHO, 2010). According to Jonkman (2005), floods alone killed 100,000 persons and affected 1.4 billion people in the last decade of the 20th century. The frequency and intensity of floods in recent years (EM-DAT, 2006) has raised a lot of questions as to whether it is linked to anthropogenic activities.

Several studies (Milly *et al.,* 2002; Bronstert, 2003; Christensen, 2003) indicate that land use changes could be behind the recent frequent and erratic floods. While other studies (IPCC, 2001; WHO, 2010) link the flood problem with climate variability and climate change.

Flood problem has been reported almost everywhere in the world with much more pronounced effects in the developing countries (Alcantara-Ayala, 2002; ISDR, 2004) due to their low incomes, poor housing facilities, inadequate warning systems and preparedness generally grouped by Alcantara-Ayala (2002) as social, economic, political and cultural vulnerabilities.

Generally, flood disaster management involves four stages of prediction, preparation, prevention and mitigation and damage assessment (Konadu and Fosu, 2009). RS and GIS techniques have been reported to be handy in all these stages. With the flood problem expected to escalate due to increasing climate variability and change (Berz *et al.,* 2001; IPCC, 2001; Milly *et al.,* 2002; Kundzewicz *et al.,* 2010; WHO, 2010) and increased land use change (Milly *et al.*, 2002), the ability to provide fast and accurate flood information will be critical in order to minimize flood associated damages.

The increased risk of floods due to climate change and increased climate variability such as El Niño in poor developing countries has been recognized (IPCC, 2007; IGAD and ICPAC, 2007). There have always been floods which have occasioned devastating consequences worldwide. The current scenario is aggravated by climate change and human activities. Moreover, there is growing awareness of the effect of climate change on the frequency of Intergovernmental Panel on Climate Change (IPCC) predict future increases in flooding due to escalating storm activity and overall rise in amounts of precipitation (IPCC, 2007).

Climatic changes include rising temperatures and highly variable rainfall patterns, which result in increased frequency of extreme weather events such as floods and droughts. For instance, it has been reported that the last two decades have recorded six years with the warmest temperatures. Rainfall variability has been observed in sub-Saharan Africa (SSA) with decreases recorded in the Sahel region and increases in the East and Central African region. Consequently, climate-related disasters such as floods and droughts have doubled in these regions within the last quarter century. Mozambique, Malawi, Kenya, Madagascar and Ethiopia are examples of SSA countries likely to experience unexpected adverse weather patterns (World Bank, 2009).

The climate change-human-induced activity nexus is a complex phenomenon difficult to disentangle since human activities destroy the mechanisms through which nature minimizes the destructive effects of natural disasters such as floods. These have increased flood peaks and reduced flood-carrying capacity of rivers because of excessive siltation of riverbeds and river mouths with many adverse impacts. In

Kenya, floods disrupt social life, destroy property and result in loss of lives (MWI, 2009). UNEP and GoK (2009) reported that fatalities due to floods constitute about 60% of disaster victims in Kenya. In addition, floods have devastating impacts on agricultural and industrial production, manufacturing, infrastructure, tourism and public health (Mogaka *et al.,* 2006; Mango *et al.,* 2007). In Kenya, floods are very persistent in the lower parts of Tana River and the lower parts of Lake Victoria basin, particularly the Budalangi area in the Nzoia River basin, and the Kano plains in the Nyando River basin. Barely a year goes by without reported cases of damage to infrastructure, displacement of communities and loss of life due to floods.

Future rainfall projections for Kenya up to the year 2030 broadly indicate that there will be increases in annual rainfall, with highest amounts expected in western parts of Kenya around Mount Elgon, Elgeyo Escarpment and Cherangani Hills. If these projections are accurate, there are likely to be far-reaching effects on the intensity and frequency of floods in the region (Mango *et al.,* 2007; MWI, 2009).

As a result of increased frequency and intensity of floods, thousands of people living in the lowlands are forced to move to higher ground and adopt various coping measures to survive (MWI, 2009). While these coping measures may be successful in the short term, they often have severe implications for longer-term livelihood sustainability. Many of the measures people adopt allow them to survive the impact of floods but not to recover from it. The resulting loss and damage and inadequacy of coping mechanisms occasioned by floods therefore pull people into an ever-more vicious cycle of poverty.

According to Flood Mitigation Strategy (MWI, 2009), nothing has been done to update flood monitoring network. The meager resources available have instead been channeled to construction of dykes and sensitization policies. There is therefore the need to resort to technology which is comparatively cheaper and more effective for this task.

Remote sensing and GIS technology has proved to be of great importance in acquiring data for effective resources management and hence could also be applied to environmental monitoring and management of floods. These tools can be used to mitigate the impact of natural disasters. Examples include facilitating disaster planning, providing early warning, enabling vulnerability assessment by expediting population evacuation and appropriate emergency response, and improving damage assessment capability, post-disaster humanitarian assistance and subsequent reconstruction of infrastructure (Mutua, 2011).

2.9 Digital elevation models (DEM)

Some studies have analyzed the quality of the SRTM data in general, (Sun *et al.,* 2003; Smith and Sandwell, 2003; Kocak *et al.*, 2005). Ludwig and Schneider (2006) assessed the general quality of the SRTM data to evaluate their potential for hydrologic modeling in Southern Germany. They reached the conclusion that although SRTM data partially show low accuracy in mountainous terrain primarily due to radar shadow effects, the overall quality of the data sets is sufficient for hydrologic model applications in mesoscale areas. Jarvis *et al.,* (2004) concluded that for hydrological modeling SRTM DEM performs well, but that better results can be expected through digitizing and interpolating cartographic data of scale 1:25,000 and below if these are available. The SRTM DEM derives stream network and verify it against digitized stream network from satellite imagery and other published work. DEM however is not able to derive the stream network for the fairly flat landscape. An SRTM is essential in providing information on the watershed, elevation and the stream networks in an area, all these are essential in assessment of floods. SRTM image was used to carry out a stream flow analysis in order to show the flow of rivers in the areas. It was observed that the major river was River Nzoia.

2.10 Summary

The reviewed literature has shown that there has been widespread research on the Budalangi river basin majorly on social sector but a missing link on the planning for disaster especially in mapping and determining flood potential zones in relation with cultural beliefs and traits. Omondi (2008), indicated that areas prone to flood disasters should be properly defined and mapped and land use development of high population should be discouraged in flood disaster-prone areas, especially in the rural areas. This research therefore strives to bridge this gap by studying and bringing to light the need for mapping and identification of socio economic and cultural values of why residents of Budalangi are adamant to change despite the looming floods crisis in the Budalangi plains.

2.11Theoretical and conceptual framework

The theory that informs this study is the theory of planned behaviour.

2.11.1Theory of Planned Behaviour

The theory postulates that human actions are supposed to be influenced by a person's own attitude, that is, effective attitude and instrumental attitude, subjective norms, perceived behavioural control, intentions, and behaviour (Ajzen, 2005). These tenets, guide this study in trying to explain why communities at risk of flooding continue to go back to flood prone areas despite the risks. The additional component of the modified model, perceived behavioral theory (PBC) is a multidimensional construct intended to reflect perception of factors that are both internal such as the knowledge, skills, will power, and external ones such as time, opportunity, cooperation of others to the actor (Ajzen, 2005): self-efficacy and controllability, which reflects an individual's external conditions that may augment or moderate his or her ability to adopt certain behaviour (Do Valle *et al.,* 2005).

The self-efficacy component of PBC deals with the ease or difficulty of performing behaviour (Karpppinen, 2005) measured by two types of items: perceived difficulty and the degree of confidence of the actor in his ability to perform the behaviour if he wanted to. According to Ajzen (2005), the perceived control component of PBC involves people's beliefs that they have control over the behaviour. He suggests that this dimension is measured in terms of perceived control over behavioural performance, and also what appears to us to be a locus of control (Armitage and Conner, 2001; Kraft *et al.,* 2005). In line with this theory, the PBC construct predicts the specific behaviour directly and indirectly through intentions (Do Valle *et al.,* 2005).

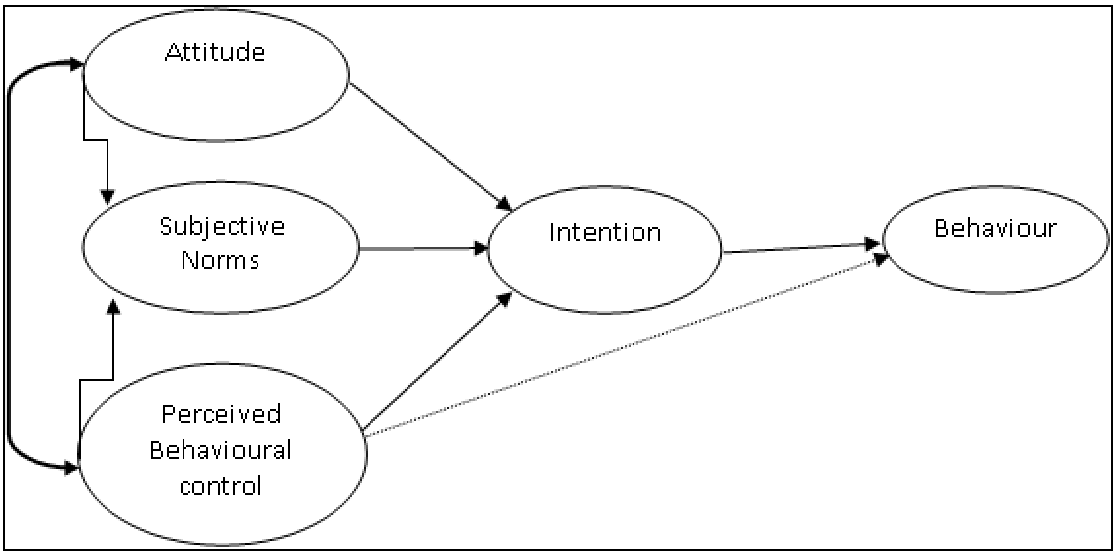

Figure 2.1: Theory of planned behavior (Ajzen, 1991)

This theory is applicable in this study since it provides information on how people react every time there is flooding. Therefore, perceived behavioural control becomes a valuable theoretical construct. This theory has been used widely in many works. It also guides the study in obtaining data on unusual behaviour of disregarding risk in spite of knowledge and experience of the risks.

2.11.2 Conceptual framework

The basic relationship explored in this study is the identification of flood risk areas and safe areas using GIS and factors that motivate the affected community to continue occupying the flood risk areas despite the risks in order to effectively manage flooding in Budalangi area. The conceptual framework indicates that to reduce the impact of flooding, there is need for the mapping of risky and safe zones and to understand why the affected community continues to expose themselves to the frequent risk.

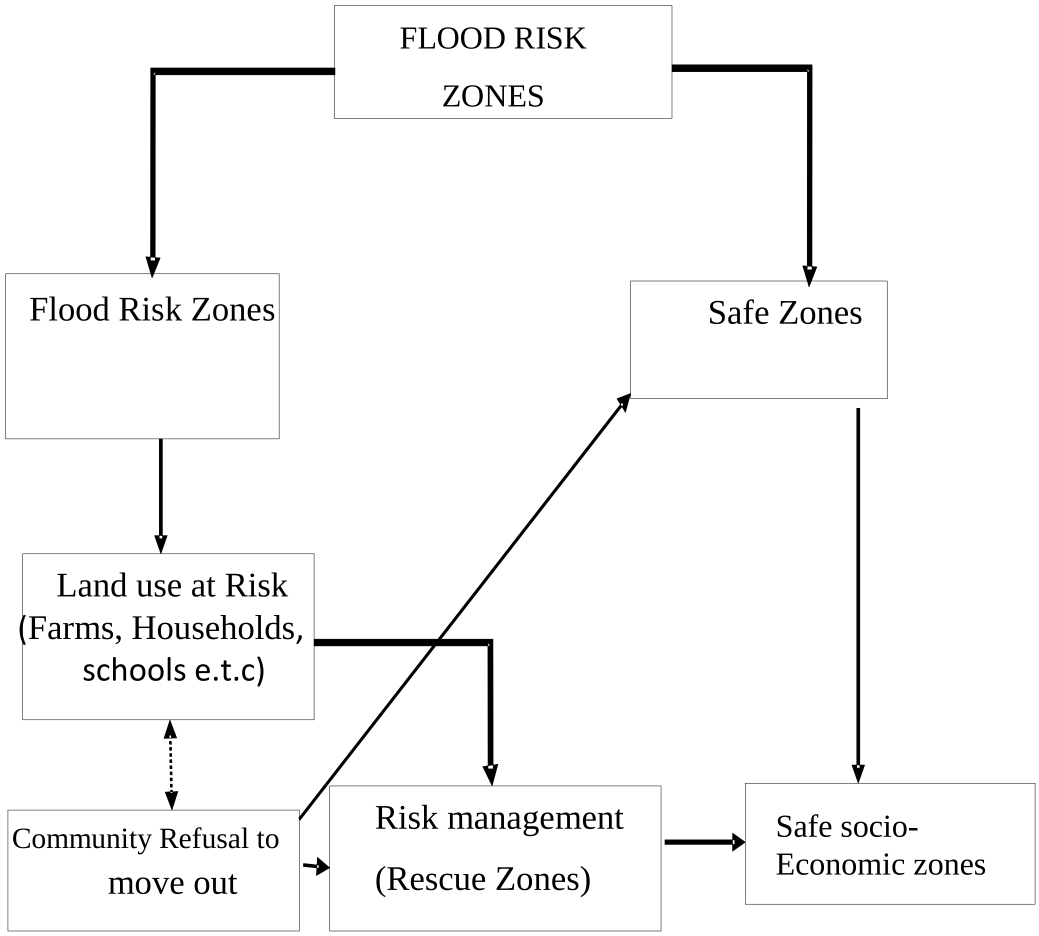

Figure 2.2: Conceptual framework (source: the researcher)

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CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This chapter details the research techniques, research instruments, data collection procedure, data analysis and ethical considerations for the study for specific objectives.

3.2 Research design

A cross sectional survey design based on questionnaires, observation and use of GPS was adopted. It was deemed appropriate because of its functionality to collect data frequencies and threshold levels of the same instances.

The study sought to delineate risk and safe zones from SRTM data by getting the maximum River Nzoia flood stage from a combination of GPS data and interviews data. The results thus obtained were overlaid with land use/land cover information derived from fairly current Landsat imagery (March 26th 2016 image) to determine the elements at risk. Field checks (ground truthing), GPS data, topographic maps and Google earth accompanied the interpretations and analysis to ascertain the derived information. This information assisted in determining the safe zones for carrying out economic activities and settlement. Determination of elements at risk was done by the aid of GPS coordinates picked systematically along the survey route. The GPS coordinates were picked and the respondents were supposed to respond whether they've experienced floods on their farms or not. The respondents who said they've not experienced flooding were deemed to be on safe zones while those who have experienced floods were deemed to be unsafe (risk zones). This was then used as the benchmark for determining flood risk zones by employing spatial analyst tool raster calculator in ArcGIS. This was done by reclassifying the elements at risk and determining their areal coverage. The socio-economic data derived from questionnaires assisted in finding out the value attached to each element.

3.3 Target population

The target population referred to all the households that were found within the upper and lower zones of Budalangi sub-county. This included Bunyala west, Bunyala North, Bunyala East, Bunyala Central, Khajula and Bunyala South.

3.4 Sample size and sample Techniques

The sample frames for upper and lower zones were selected based on the populations of the respective zones of Budalangi sub-county. It included the household heads within the lower and upper Budalangi Plains. The households for upper and lower zones were selected systematically for administering questionnaires.

3.4.1Sampling techniques

A socio-economic survey was carried out in this study. Stratified sampling technique was used to sample respondents for socio-economic data. The total population was first stratified into those living in upper and lower zones of the study areas. Then from lower zone stratum, a systematic sampling technique was done to determine the study sample population as shown in Table 3.1. This was done after ground truthing and an analysis of land use land cover and potential flood risk was established, so as to ensure that the sample population strides across various land uses within the risk zones.

The respondents were selected systematically from the population based on locations representation as shown in Table 3.1. This was done by calculating the sample sizes based on households as the frame.

3.4.2 Sample size

The sample were calculated using data from population and Census 2009. The formulae for sample calculation was adopted from Yamene, 1967 where:-

$$n = \frac{N}{(1 + Ne^2)}$$

N=Population/Household

E =Sampling error 0.2

n=Sampled population

Table 3.1: Sample population

Zone	Locations	Tot Population (N)	Sampled population *(n)*
Upper	Bunyala west	3521={3521/(1+3521x0.04)}	25+4=29
	Bunyala North	2710={2710/(1+2710x0.04)}	25+2=27
	Bunyala East	3318={3318/(1+3318x0.04)}	25+3=28
Lower	Bunyala Central	2470={2470/(1+2470x0.04)}	25+1=26
	Khajula	1762={1762/(1+1762x0.04)}	25+1=26
	Bunyala South	1464={1462/(1+1464x0.04)}	25+1=26
TOTAL		**15,245**	**150+12=162**

*plus to take care of non-returned questionnaires. The targeted sample size was 150 household, 15 extra questionnaires were added to take care of the non-responses therefore the researcher was only able to retrieve 12 out of 15 questionnaires.

The sample frames for upper and lower zones were selected based on the populations of the respective zones of Budalangi sub-county. It included the household heads within the lower and upper Budalangi Plains. The households for upper and lower zones were selected systematically for administering questionnaires.

The households were systematically selected and since the number of the households per locations were not equal the n^{th} value for each location varied. The highest n^{th} value was in Bunyala west location with 121 households as the n^{th} value. The samples were picked following the n^{th} value for instance in Bunyala West with 3521 households, to obtain a sample of 29 households, 1 household was obtained after every 121 households. The starting point was obtained randomly from the first thirty households from the chief's office. Same sampling procedure was done for other locations following their respective n^{th} value. This is illustrated in the table 3.2 below.

Table 3.2: Households nth value determination

Location	**Households (N)**	**Sampled**	**n^{th} value**
Bunyala west	3521	29	121
Bunyala North	2710	27	100
Bunyala East	3318	28	119
Bunyala Central	2470	26	95
Khajula	1762	26	68
Bunyala South	1464	26	56

3.5 Research methods

3.5.1Observations

Observation was done in order to complement the information provided in the questionnaires. The observations were captured in note books which were supplemented by photography. These observations were key on current land use practices and flood control measures in the areas in order to validate the current land uses for digitization purposes.

3.5.2 Research instruments and equipment

These comprised of materials and tools required for specific objectives to be realized. They encompassed questionnaire, field checklists, cameras, Global Positioning systems and topographic maps. These sets of tools were used to collect both qualitative and quantitative data for data analysis.

The questionnaires were used to collect data from the upper and lower zones from the 162 households sampled as per Table 3.1 above. Field check list was used in collection of information that was not captured by the questionnaires which included emerging economic activities. GPS picked Elevations of various households and their spatial location for mapping of elevations and ground truthing.

3.5.3 Validity of research instruments

The instruments for data collection were subdivided as per the variables and objectives to ascertain whether the content was comprehensive and representative of the behaviour domains that were measured. Content validity of the instrument was determined through expert judgement which involved discussing the items in the instruments with the supervisors, lecturers and colleagues. Before the actual field survey, a detailed pilot of the questionnaires was carried out in the field. This aided in checking questionnaires reliability, readability, interpretation and their applicability in the field. The local measures to counter floods was also factored into the questionnaire, (Appendix I).

3.6 Data collection procedure

The methods for data collection included both primary and secondary sources. The primary sources involved firsthand information that was obtained from field visits, image analysis, topographic maps, filling of questionnaires, filling of checklist through observation and photography. Secondary data was obtained from review of books and literature from both the library and the internet.

The data collection procedure followed a defined path as shown in Figure 3.1. The initial stage was data acquisition from SRTM, interviews with local key informants, acquisition of Landsat images and GPS information from the field, this was then preceded by preparation of the images using various software’s to come up with elements at risk.

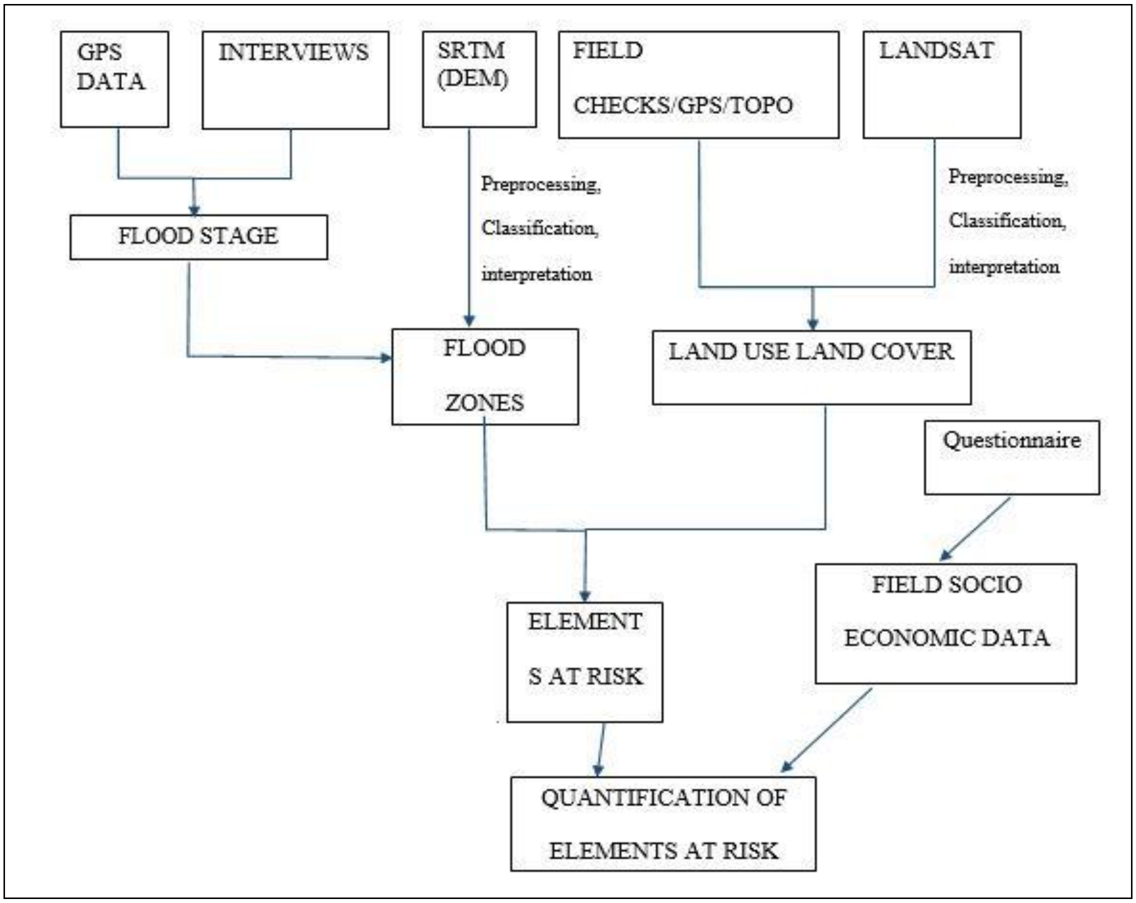

Figure 3.1: Data collection procedure

3.6.1The primary data

The first primary data required for the study was satellite data which constitute SRTM (Digital elevation data), a 2016 March Landsat image of Budalangi basin.

3.6.1.1Questionnaires

The major source of primary data was from questionnaires which were structured to be filled by 162 respondents from six locations. The questionnaires were structured into five sections which included; Sections (A-F) of which A _Respondent details, B _ Demographic or general information, C-Economic background of community, D- Area residents' perception of socio-economic costs of inhabiting flood prone area, E- specific question structured on likerth scale addressing the specific objectives and F-strategies for flood management, see Appendix I.

3.6.2 Secondary data

3.6.2.1 SRTM

SRTM covering the study area was acquired with a spatial resolution of 90m by 90m. The SRTM image was projected to Universal Transverse Mercator in datum WGS 84, zone 36N. This projection was used for all the other data that was acquired to ensure uniform projection of the data used for the study. An SRTM is essential in providing information on the watershed, elevation and the stream networks in an area, all these are essential in assessment of floods.

3.6.2.2 Landsat images

Landsat images give information on the land covers of the earth's surface. These images are therefore important in determining the land cover types and the land uses present in the study area. A fairy recent Landsat image was acquired for this study. Efforts were made to acquire surface reflectance Landsat data, since the reflectance of different objects on the earth's surface can easily be identified with different band combination. The quality of the data was ascertained. For consistency and ease of data manipulation, the same reference system as SRTM data was adopted. Landsat data has a spatial resolution of 30m by 30m.

3.6.3 Topographic maps

Topographic map of the area at a scale of 1:50,000 was used to supplement the elevation data from SRTM. The scanned map was geo-referenced prior to use. Place names and other supplementary data was acquired from topographic map of the area.

3.6.4 Existing data

These were acquired from the previous researches, journals, books and papers through searching of the databases.

3.6.5 Identification and mapping of the flood prone areas

The peak flood stage was used to delineate the safe and risk zones. The peak stage value was determined through a combined procedure of purposive interview and recording of the elevation from the GPS. Several elevations were recorded through these interviews using a GPS. The flood risk zones were determined through the respondents experience to floods and of all the respondents who indicated that they have never experienced floods on their farms, were deemed to reside in safer zones.

This procedure identified a threshold, and, areas above this threshold were considered safe and regions below were assumed to flood. A Boolean reclassification was performed on the clipped SRTM to give only the flooded and the non-flooded regions. Areas that flood were assigned a value of 1 while values above the threshold were assigned value of 0 to show the areas that don’t flood.

The total areas of the reclassified images were calculated using the pixel values available from the clipped images, the pixel measurement were obtained from the image metadata which includes pixel size and number of pixels (count) per scene. This was done for the different regions (flooded and the non-flooded), which gave the areas and the percentages of the flooded and the non-flooded regions from the total area of the sub-county. The calculated areas and the percentages were then exported to SPSS and represented as pie charts.

3.6.6 Mapping elements at risk

Using the Landsat images, land uses and the land cover of River Nzoia flood plain were deduced. False color composite was done using bands 5, 4 and 3 (NIR, Red and Green bands). Thereafter, unsupervised classification was performed on the images to attain the spatial representative land uses and the land cover types present in the area of study.

The impact of flooding on the land uses was determined by overlaying the flooding map on the land use/land cover map. The land use overlay was done by overlapping contours obtained from DEM and the flood zones were defined by the equation Area ≤1143m which were coded as either 1-Flood zones and 0- safe zones, then the study had to determine 1 (Flood zones) that were off the link of River Nzoia by using the equation (Area≤1143=1) this gave out the actual flood zones omitting zones confined in areas above 1143m. The map of the flooded areas and the land uses in it was clipped to show the land uses within the flooded areas that are affected. Using ArcGIS software the acreage of the land uses within the flooded areas was calculated then SPSS was used for charting and interpretation.

3.7 Data analysis

Data analysis was done using a combination of softwares and applications. ESRI ArcGIS software was selected to analyze images and analysis of flood risk zones, ESRI software is sorted for because of its reliability and potential to be handled. SPSS was used for analysis of quantitative data. The various types of data were analyzed as explained below.

3.7.1GPS data and image preparation

GPS coordinates of all the areas visited were taken. The elevation component of this data together with the interviews were used to determine the peak flood stage. Locations from Landsat image interpretation that required field checks were also reached through the guidance of the GPS. All sample locations were mapped using the GPS data.

The images were prepared using ArcGIS and the preparation was done to reduce noise and fill in voids in the areas for stream flow analysis. The two sets of images SRTM and Landsat images each was preprocessed before analysis. The SRTM was clipped to the dimensions of the study area and the images mosaicked together since it covered two scenes. The image was then filled and stream flow analysis done to show the flow of rivers in the areas. It was observed that the major river was River Nzoia. Figure 3.2 below shows River Nzoia and its tributaries after filling and conducting flow accumulation and flow direction.

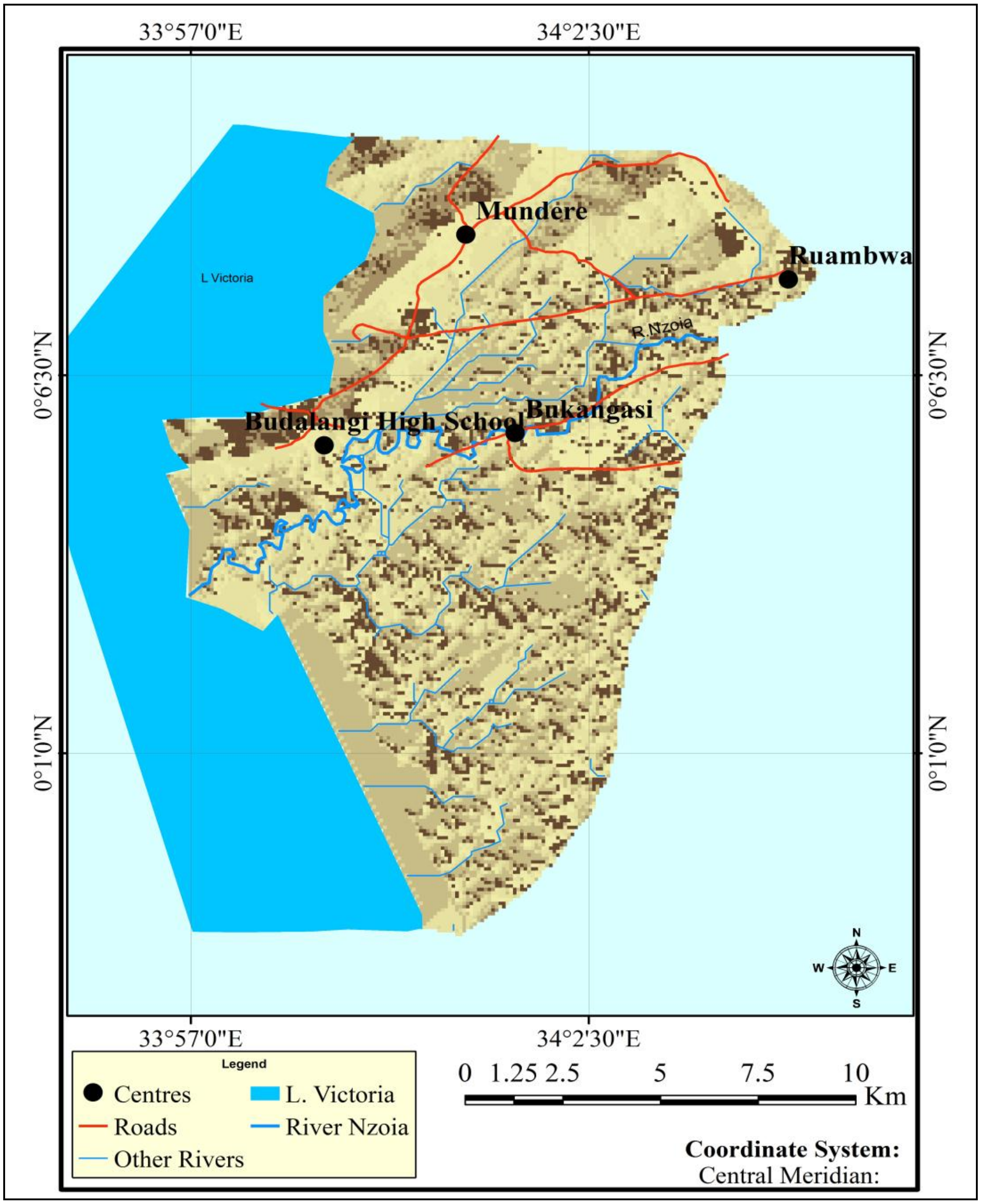

Figure 3.2: Flow accumulation and flow direction image

The Landsat images comprising of 2016 March 26th was analyzed using ArcMap. The land use was determined by conducting unsupervised classification of the land uses in the areas to determine the Land use land cover. The signatures were created to match the five categories of land uses that included Farmlands, Build up, Land Vegetation and Riverine/ Aquatic vegetation.

3.8 Ethical considerations

Carrying out a social research where study population is composed of people trigger suspicion and subsequent withdrawal of responses. Ethical considerations were taken into account in order to protect the study subjects. The respondents were also assured of anonymity and confidentiality because I sought for their consent. A research permit was obtained from the concerned arm of the Government (NACOSTI) before the actual collection of the required data from the field.

CHAPTER FOUR: RESULTS, ANALYSIS AND DISCUSSIONS

4.1 Introduction

This chapter contains the presentation of results in form of graphs, charts, pictorials and discussions. The chapter is arranged into three broad sections; general background information, land use land cover in the area and economic activities, reasons why residents don't want to move from their areas and the impacts from flooding.

4.2 General Background Information

In order to examine variations on factors that motivate the affected households to continue occupying the flood risk areas, it was important to collect data on the demographic profiles of the respondent's households. This has been highlighted in similar studies by Nduku, (2013) and Ambuchi, (2011) where demographic profiles were used to give a clear picture of the respondent's nature and characteristics. These demographic elements include: gender, age, marital status, level of education, among others. Around 50% of the residents, have lived in the area for more than 20 years, while only 14.8% have lived for 5 years or less, (Table 4.1).

Table 4.1: Duration lived in village

Duration lived in the village	**Frequency**	**Percent**
Last 5 Years	24	14.8
Last 10 Years	26	16.0
Last 20 Years	31	19.1
Over 20 Years	81	50.0
Total	**162**	**100**

In terms of gender, majority of the respondents were females (61.1%), while males comprised of 38.9%. Around 80% were married, 12% widowed, 7% single and only 1% divorced/separated. This is shown in Figure 4.1. The females and married couples represented the highest percentage since they were the ones available at homesteads during the survey. This is due to the cultural attachment that women should take care of the homes while men are at work and that's why there was a high percentage of married respondents as attributed to the culture.

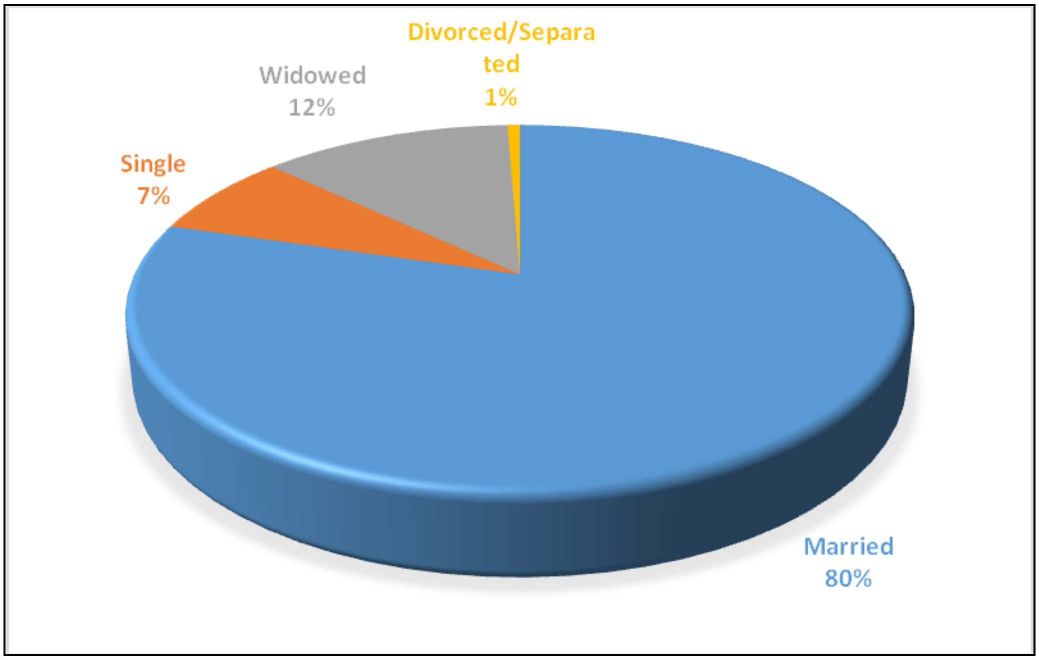

Figure 4.1: Marital status

The dominant age bracket was 31-40 years, which had 32.7% of the respondents (of which women were 33.33% and males 31.7%) followed by 25.3% (of which 28.6% were males and 23.2% were females), this is shown in the Table 4.2 below.

Table 4.2: Age-sex Category of Respondents

Age category	**Male %**	**Female %**	**Total**
18-30 Years	20.60	26.30	24.10
31-40 Years	31.70	33.30	32.70
41-60 Years	28.60	23.20	25.30
Over 60 Years	17.50	15.20	16.00
Total	**100.00**	**100.00**	**100.00**

In terms of education 61.7% of the respondents had attained at least primary education, with a higher percentage, 60%, being males while those females who had acquired primary education were represented by 40%. Further 3.1% had attained tertiary level of Education. It is worth noting that a considerable percentage had not attained formal education which was represented by 17.3% of all the respondents (Table 4.3).

Table 4.3: Level of Education of respondents

Education level	**Male %**	**Female %**	**Total**
Illiterate	9.5	22.2	17.3
Primary	63.5	60.6	61.7
Secondary	23.8	14.1	17.9
Middle level	3.2	3.0	3.1%
Total	**100.00**	**100.00**	**100.00**

4.2.1 Land ownership and acquisition

Land is considered as a key factor of production, and owning land signifies food security and a means of production especially in the fertile Budalangi plains. According to the findings of the study land ownership in the area is majorly through family ownership/inheritance. The study found out that 93.8% of the land as per the respondents swas owned by the family while 6.2% do not own any land in the area. Out of the 93.8% of land owners 72.8% was inherited while 19.8% was purchased (Table 4.4, 4.5, 4.6).

Table 4.4: Land ownership by gender

Gender	**Landownership**	**Frequency**	**Percent**
Male	Own The Land	60	95.2
	Do not own the land	3	4.8
	Total	**63**	**100**
Female	Own The Land	92	92.9
	Do not own the land	7	7.1
	Total	**99**	**100**
TOTAL		**162**	**100**

Table 4.5: Level of education and Land ownership

Land Ownership	**Education Level**	**Frequency**	**Percent**
Own Land	Illiterate	27	17.8
	Primary	99	65.1
	Secondary	22	14.5
	Middle level	4	2.6
Don’t own Land	Illiterate	1	10.0
	Primary	1	10.0
	Secondary	7	70.0
	Middle level	1	10.0

Table 4.6: Flood risk zones and Land ownership

Land Ownership	Zones	Frequency	Percent
Own Land	Risk of flood	100	65.8
	Safe Zone	52	34.2
Don’t own Land	Risk of flood	3	30.0
	Safe Zone	7	70.0

Figure 4.2: Land acquisition

The land owned by the respondents were considerably average size (1-2 acres) and it was majorly used for subsistence purposes only. The land ranged from less than 1 acre which was owned by 17.9% of the respondents while the minority owned more than 5 acres and the majority owned 1-2 acres of land, as illustrated in the Table 4.7.

Table 4.7: Land size in acres

Land size	Frequency	Percent
Less than 1 acre	29	17.9
1-2 acres	48	29.6
2-5 acres	24	14.8
More than 5 acres	14	8.6
Unknown	47	29.0
Total	**162**	**99.9**

4.2.2 Economic activities

The respondents stated their major and other economic activities in the zone and it was found out that 51.2% engaged in mixed farming, Table 4.8 and Figures 4.4, which included cattle keeping and crop cultivation. Up to 13.6% of the respondents are engaged in fishing activities, while 0.6% carry out sand harvesting (Plate 4.1). This is attributed to proximity to River Nzoia which is endowed with both fish and large sand deposits. Magombe Central, Nyadorera and Suba were the only villages where some respondents indicated they only kept livestock, (Table 4.8)

Plate 4.1: Boat services (Fishing) and sand Harvesting

Table 4.8: Economic Activities Respondents are engaged in

Economic activity	**Respondents**	**%**
Crop farming	48	29.63
Mixed farming	83	51.23
Fishing	22	13.58
Sand harvesting	1	0.62
Livestock keeping	3	1.85
No response	5	3.09
Totals	**162**	**100.00**

The other economic activities in the area included the following; agroforestry, basket Making and weaving. Barber, boating, Boda boda operator, shop keeping business, flour milling, hair dressing, tailor and civil servant.

The study area is in a rich agricultural valley and the major economic activity accounting for half of all the activities is mixed farming, Table 4.8, this has also been linked to the rich sediments from upstream areas that carry nutrients and fertilizers downstream enriching the area (Gathenya *et al.*, 2011). The study further sought to establish from households major farming activities they engage in given the dominance in farming. It was observed that cropping only was done by 27% while livestock keeping was at 1.2% and agroforestry was at 0.6%, mixed farming dominated with 51.2% (Figure 4.3). The low percentage in agroforestry could be attributed to the land size which is considerably small and not enough for agroforestry, of the 0.6% who did agroforestry it was found that they owned land of more than 5 acres while those with less than 1 acre to 2 acres were majorly crop growers and owned at least one cow and a sheep.

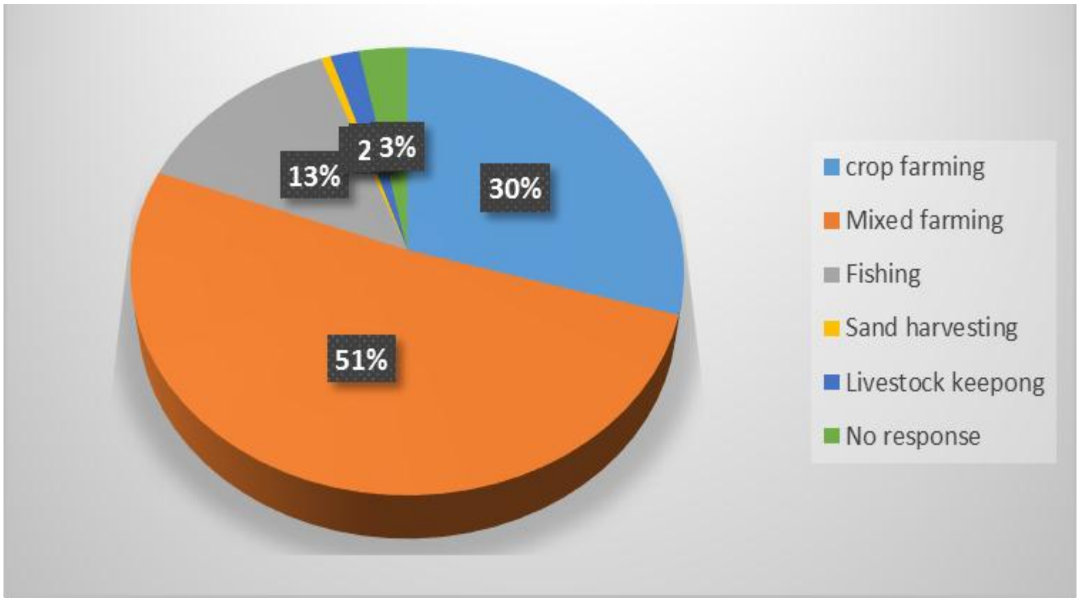

Figure 4.3: Economic activities

4.3 Land use and land cover

In order to map land use activities that are at risk, land use land cover analysis was important and the researcher conducted this using March 2016 image. The land use in the area was determined by performing unsupervised classification on a false colour image, the false colour image is deemed useful in land use analysis since the colour bands are more distinct. The unsupervised classification is also necessary to delineate the land use based on vegetation reflectance. The false colour image Figure 4.5, shows a higher percentage of "red and red tones" which indicates that there is a high area under vegetation, while the white patches indicates bare ground and build up areas. The study of Land use land cover is essential in determining the geospatial location of economic activities in the area and placing them under the safe or unsafe zones based on their location. This study sought to delineate activities at risk (since land use land cover like riverine vegetation of swamp papyrus cannot be indicated to be at risk while activities like build up and farmland can be indicated to be risky zone).

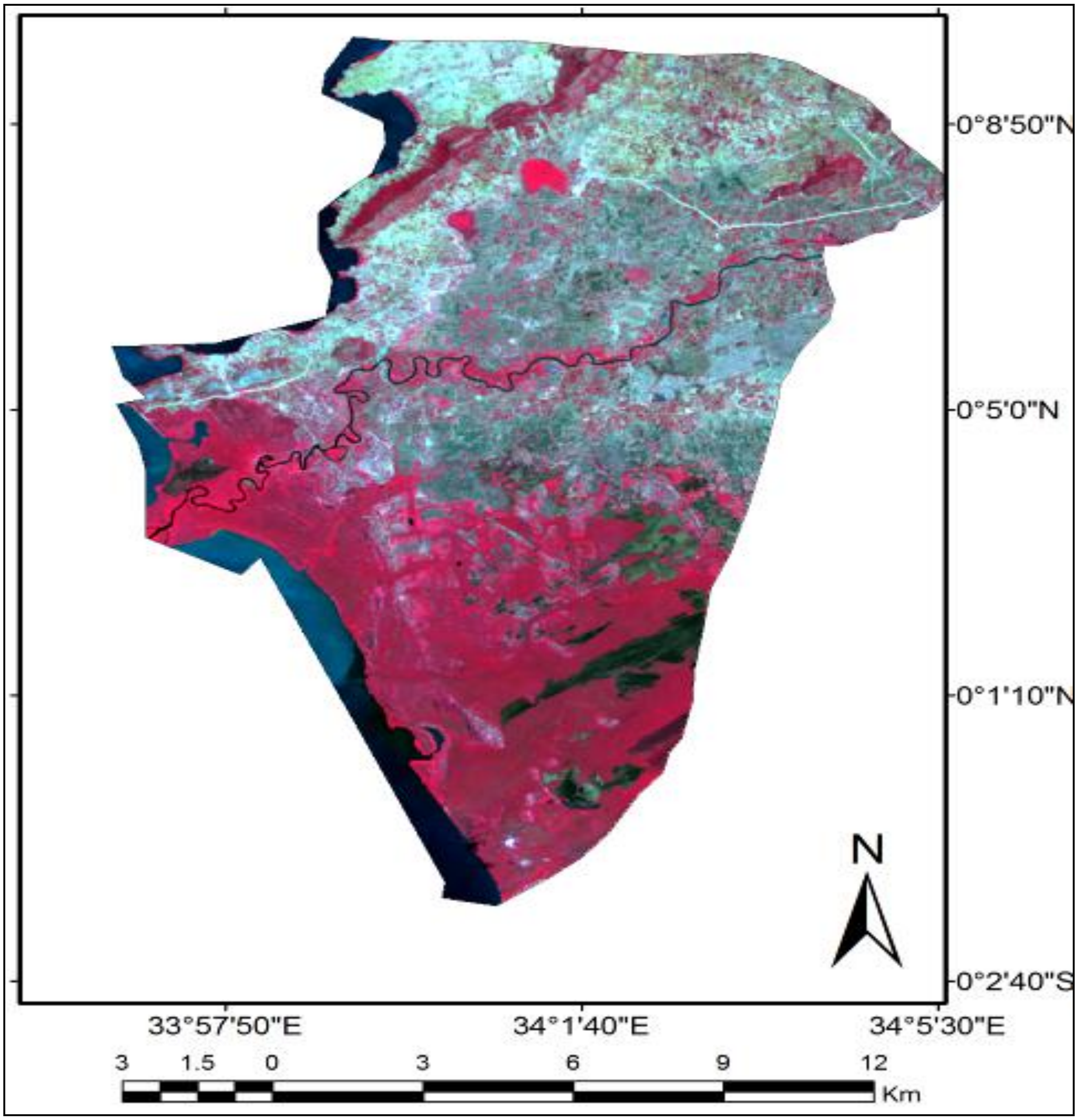

Figure 4.4: False colour image

The land use classification was determined by unsupervised classification- Pixels were grouped based on their reflectance properties acquired automatically by the computer, the choice of unsupervised classification over creation of signatures was due to the vast extent of the area and reclassification of the output was done to correct outlier pixels giving an accurate land use. These groupings are called "clusters"**.** The user identifies the number of clusters to generate and which bands to use- and it was found out that 36% of the total land was under farmland which was represented by 69.9km^2 and the least was under aquatic and riverine vegetation covering 9%, Figure 4.5 below.

Flooding is a major environmental threat as may be proven by the many flooding events worldwide over the last 10 years (Van der Sande *et al.*, 2003), this poses an eminent threat to almost half of the study area which causes an acute food shortage in the area, as Van der Sande *et al.*, (2003) put it that the destruction from floods are majorly related only to water depth, although flood damage is controlled by various other variables. Budalangi being in a developing country cannot cope when floods strike hence being severely incapacitated.

Table 4.9: Land use of the area

Land use	**Area (km^2)**	**Percentage (%)**
Aquatic/Riverine	17.26	9
Farmland	69.94	36
Buildup/Bareground	40.50	21
Vegetation/Papyrus	67.33	34
Total Area	**195.02**	**100**

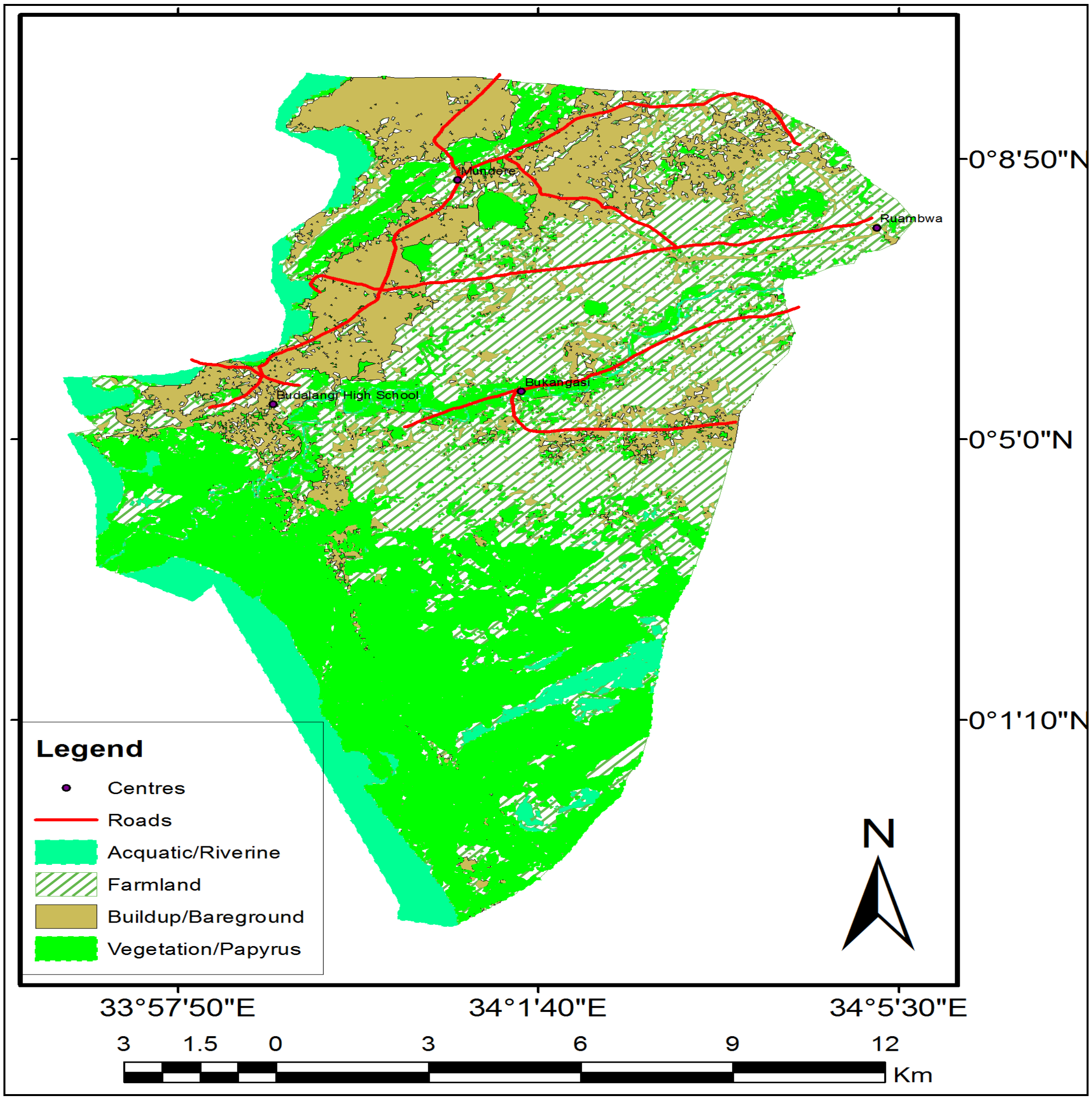

Figure 4.5: Land use distribution map

4.4 Flood risk areas

4.4.1Flood risk zones

The study sought to determine flood risk zones in the area by employing the use of GIS technique, which was used to map Flood risk zones in Budalangi and it was observed that there were 61% of safe zones in the areas while 39% were flood prone zones which were represented by 76.16km^2 and safe zones was represented by 119.77km^2 a total percentage of 61% (Figure 4.6 and Figure 4.7).

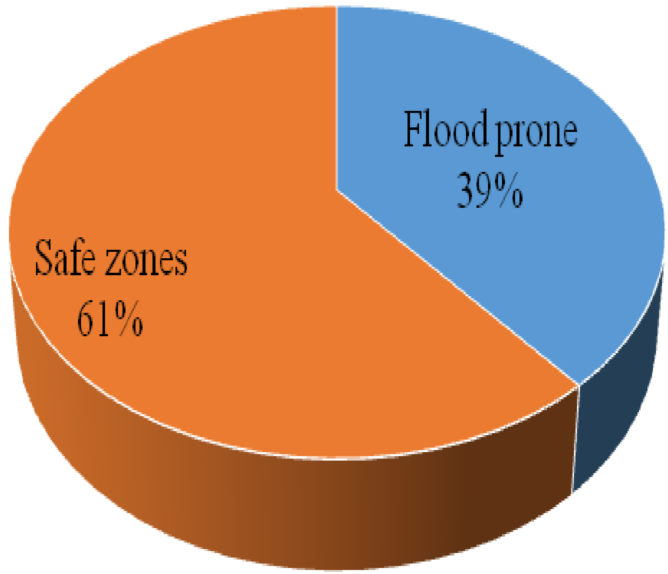

Figure 4.6: Flood risk zones

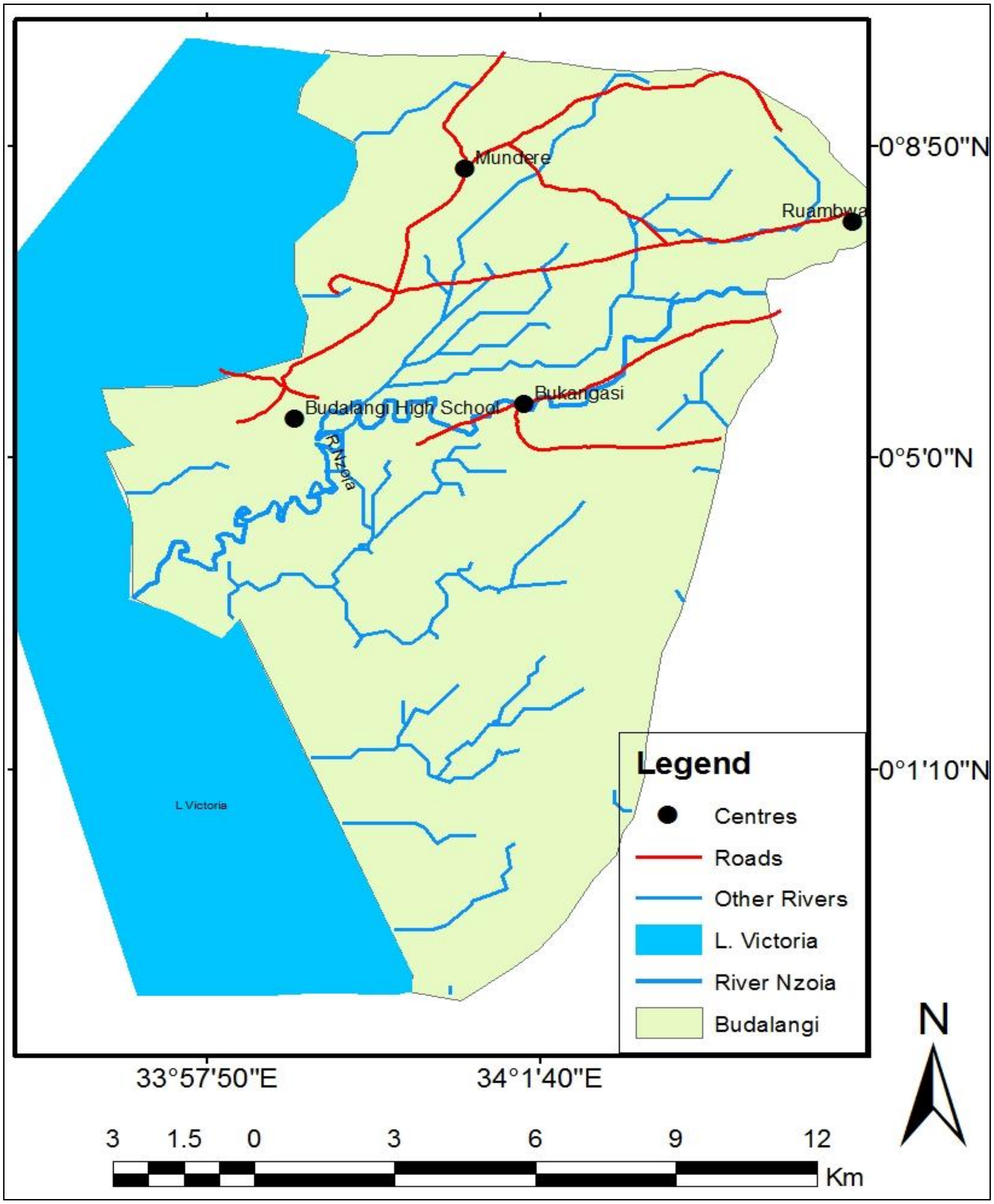

Figure 4.7: River accumulation zones

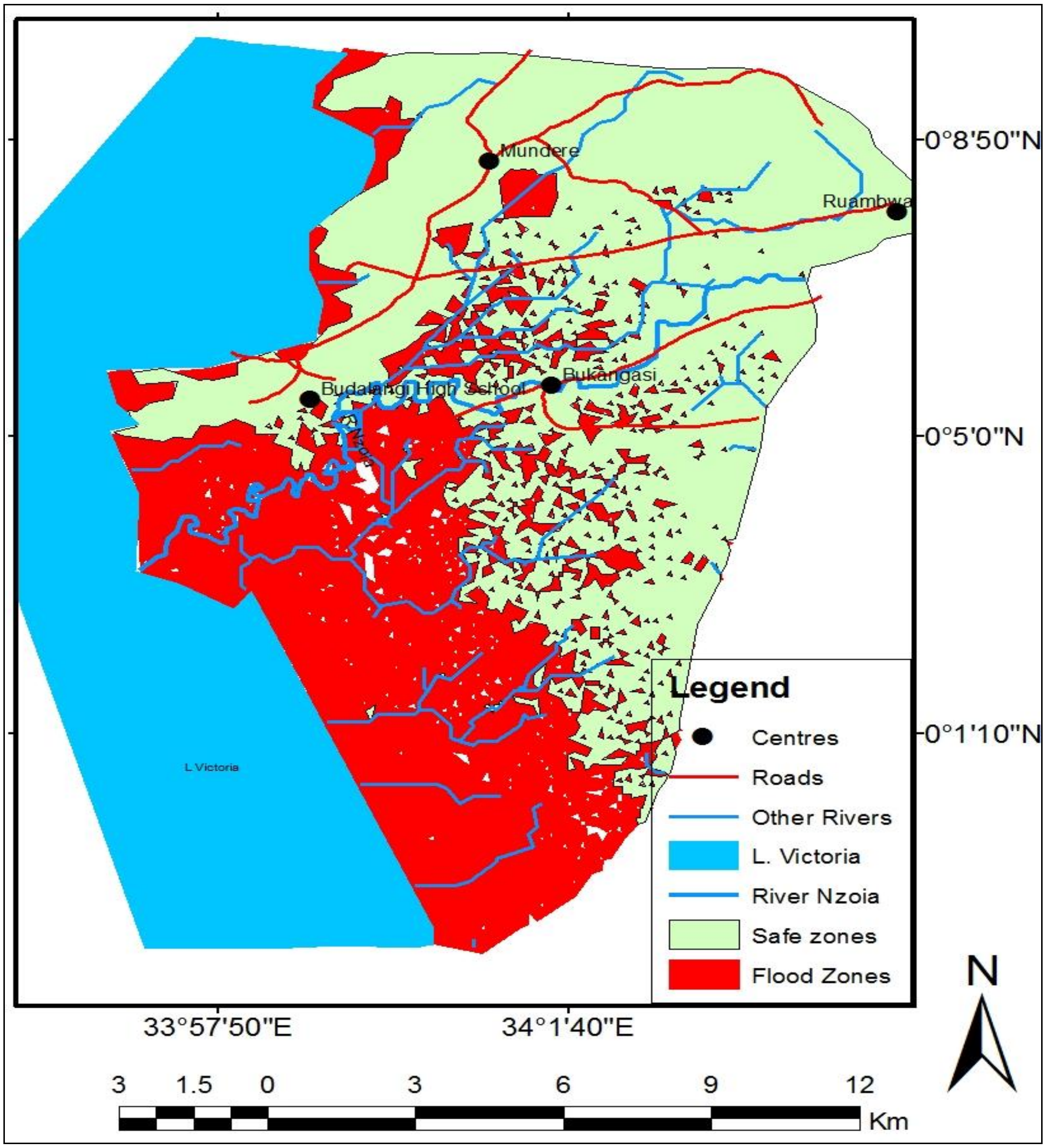

Figure 4.8: Flood and safe zones map

Flooding does not necessarily occur on all the flood potential prone zones since some areas lie under 1144m above mean sea level but they are not necessarily in contact with the river. This could be due to high grounds surrounding it (Figure 4.9). It was therefore prudent to determine the actual area that will be affected by floods by determining areas that are flood potential but in contact with the rivers in the area.

It was found that spot flooding occurred on some sections on the upper side of the study area while 90% of the unsafe zones were to the lower side of the area. A total of 68.58 km^2 of the total $75km^2$ was high risk flood potential zones.

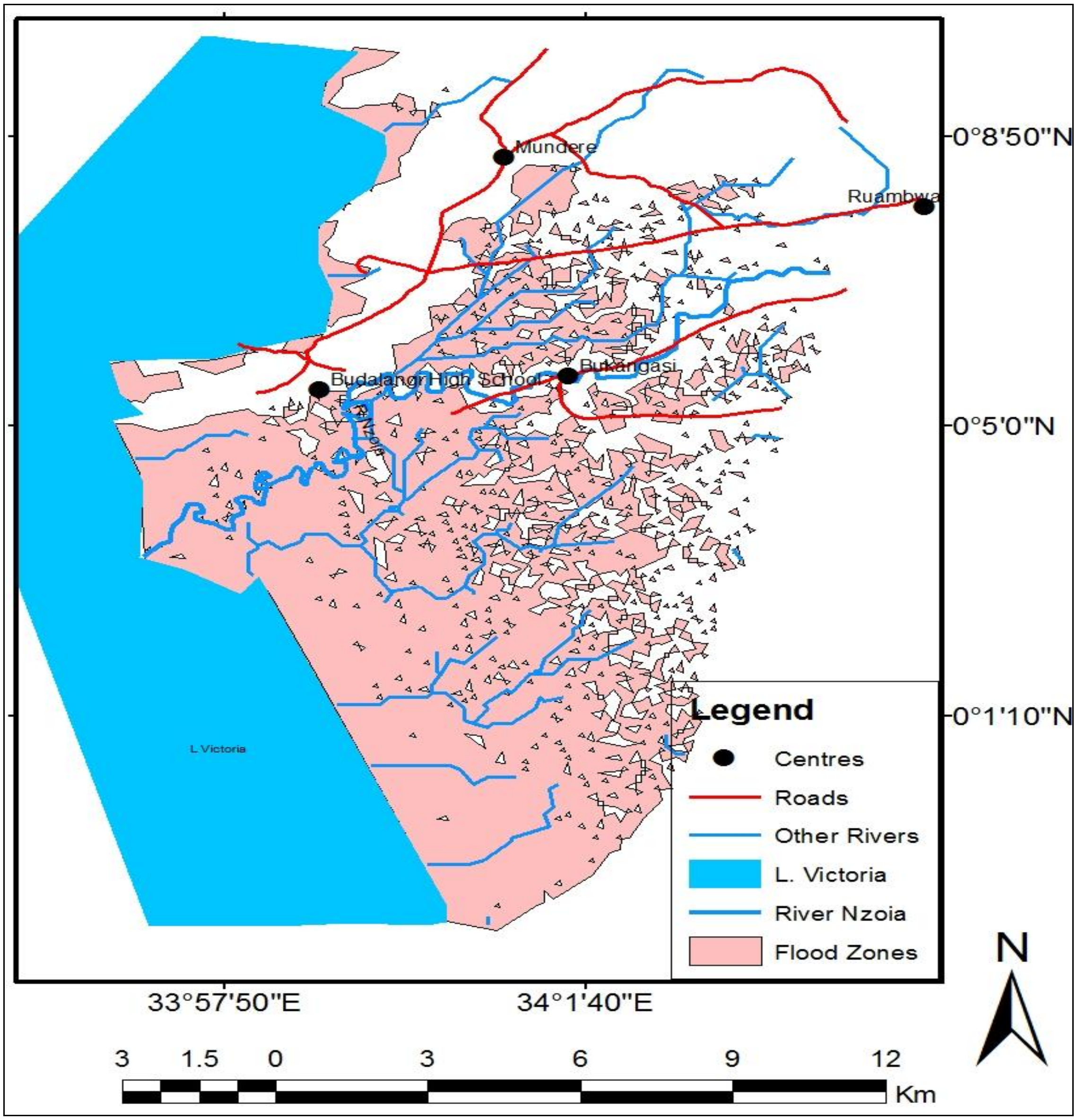

Figure 4.9: Flood zones map

4.4.2 Safe Zones for economic activities and evacuation

Safe zones were established by determining from the general safe zones areas that are actually more than 1144m above mean sea level. This was found to be true in the area and the exact safe zones that were meeting this criterion was 120km^2 of the total land cover. It was observed that the upper sides of the river were safer than the lower zones of the river. Budalangi High School, Bukangasi, West Bunyala Location to East of Mundere has 90% safe zones while Musokoto village is also a safe zone, (Figure 4.10).

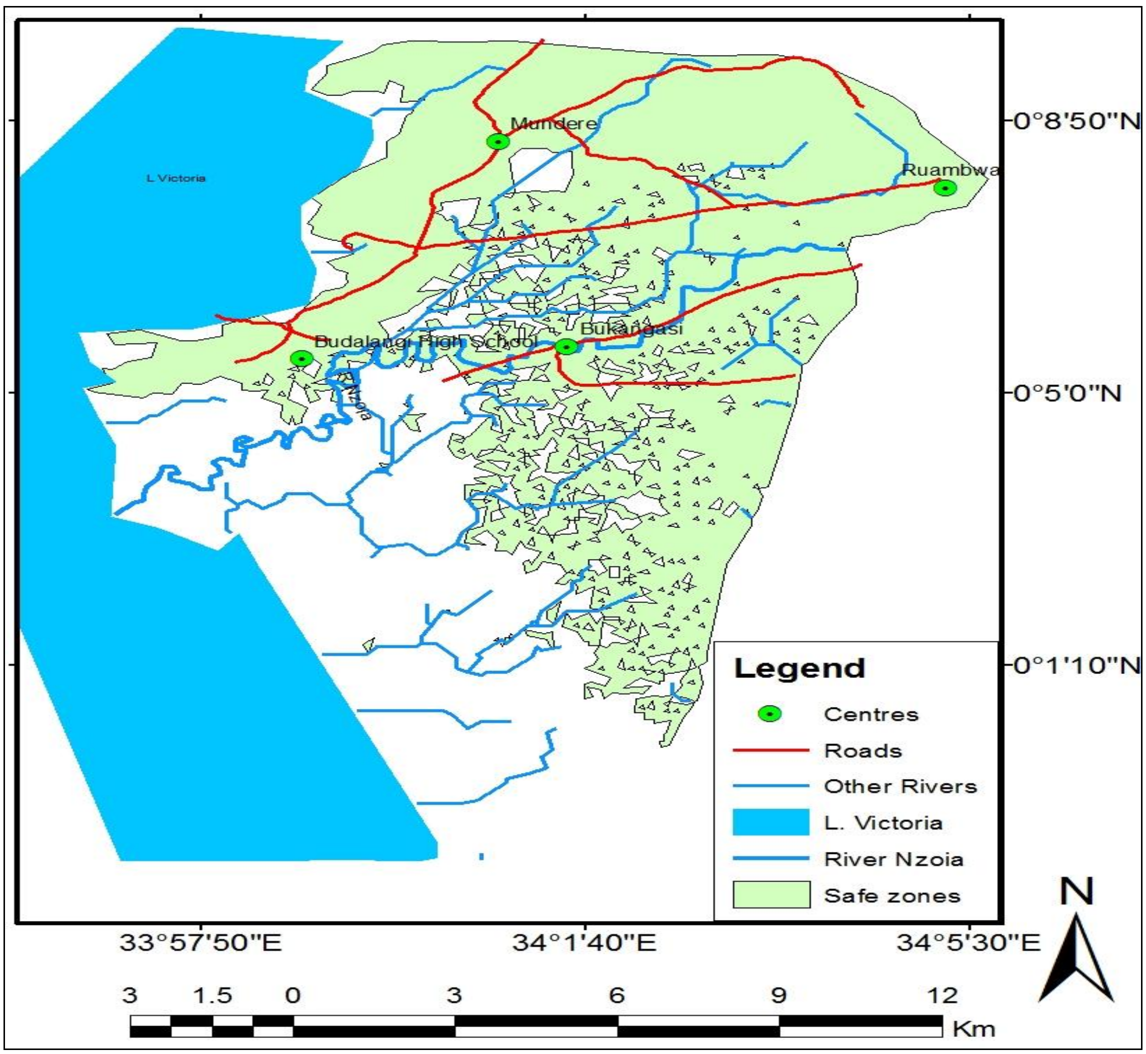

Figure 4.10: Safe zones map

4.5 Elements at a high risk of destruction by flooding

It was found out that 19% of farmlands and 55% of build-up areas were at a risk of destruction by floods. These were homes, schools and churches in the areas with farms containing food products. Schools are at a risk of flood damage with granaries also facing a real danger drawing the families living in the flood zones areas at a greater risk of food insecurity.

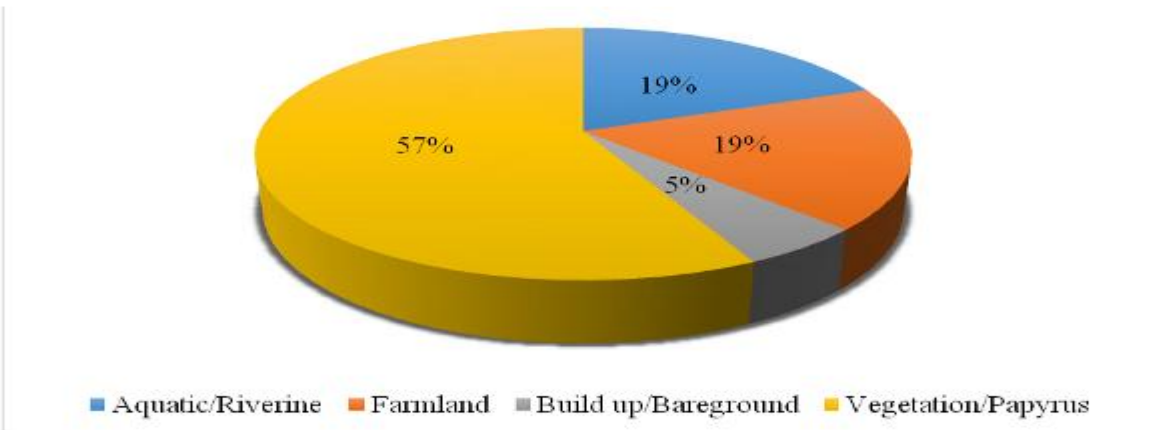

Figure 4.11: Elements at high risk

This accounted for $12km^2$ of farmland and $3.5km^2$ of buildup areas were at a greater risk of destruction by floods.

Table 4.10: Elements at high risk area in km^2

Land use	**Area (km^2)**
Aquatic/Riverine	13.0598
Farmland	12.4645
Build up/Bare ground	3.58315
Vegetation/Papyrus	39.0319
Total Area	**68.1393**

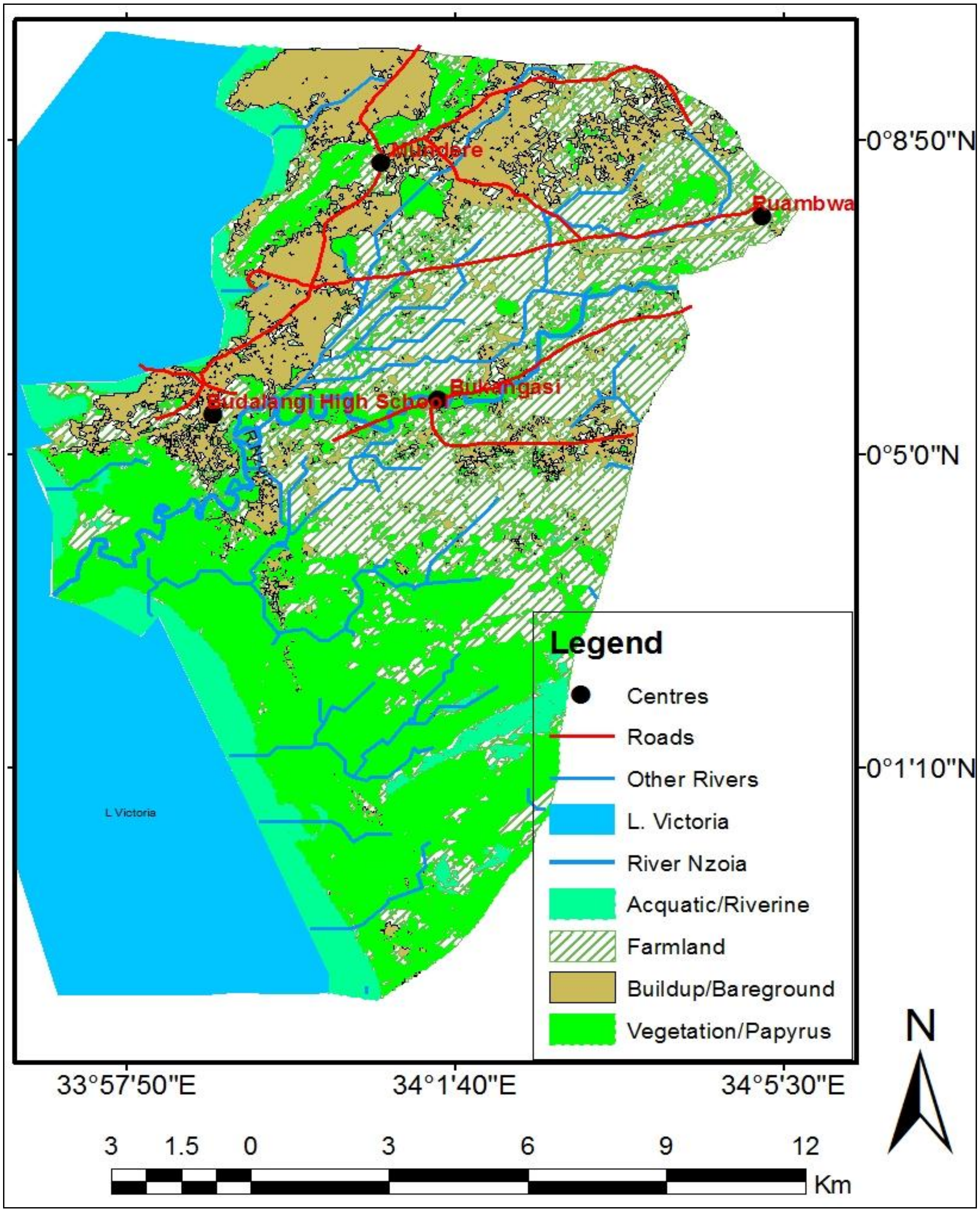

Figure 4.12: Map of Economic elements at risk of Flooding

4.5.1Extent of flood risk areas

Based on the different land use determined in Figure 4.12, the interview questionnaires were administered and farmers were asked if their farms have ever experienced flooding. According to the findings 96.9% of the respondents indicated that they've experienced flooding on their parcel of land only, while 2.5% said they had not experienced floods on their farms, this is in line with Ochola (2009) where severity and magnitude of flood prone people in Nyando was at 97% and 3% experienced very low vulnerability. Of those who stated that they have not experienced flooding on their farms (2.5%), majority don't own land or have their farms on the higher grounds, this indicates that floods in the areas of Western Kenya are so disastrous that it affects a higher number of families.

The study further sought to establish the frequency with which the households have experienced flooding on their farms, as per elevation status those who said they've never experienced floods either at their homesteads nor farms lived above 1143m ASL. The results show that 50% of the respondent's experience floods very often while 2.5% said they never experience floods (Figure 4.13).

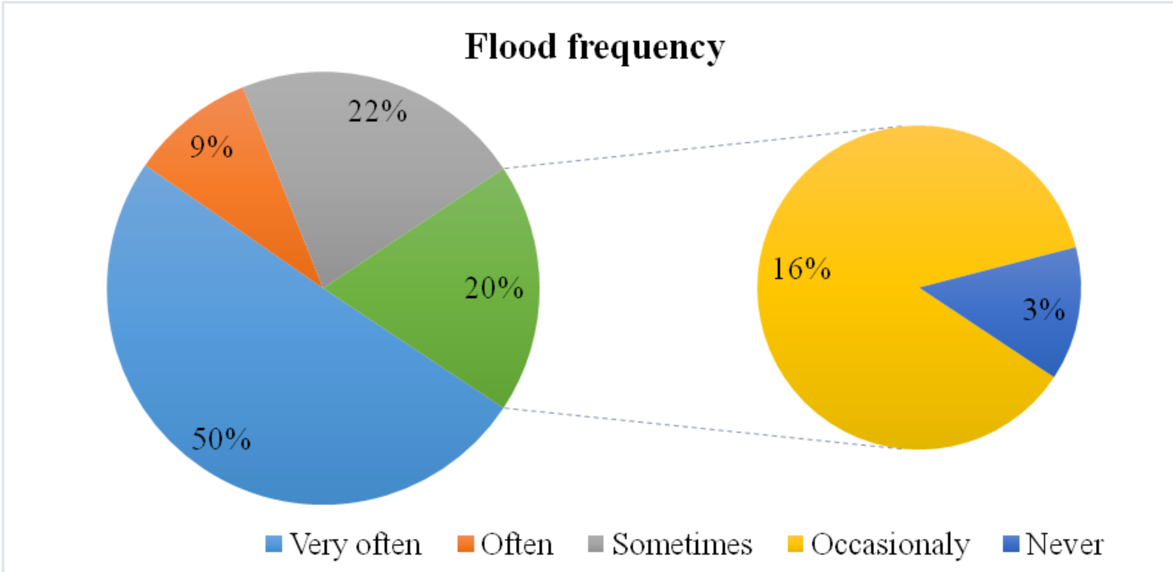

Figure 4.13: Flood frequency

4.5.2 Property damage

Based on the frequency of flooding affecting households that fall within the different land cover zones, the study sought to establish the extent of property damage in the area, this was observed to be of great significance and greater than 50% of damage on property was reported by 79.6% of the respondents while 6.2% reported damage of less than 25%. The severity of the damage is quantified by the locals in terms of crops and houses destruction by flooding. The most affected property are crops on the farms, with half of the population doing mixed farming. There are immense losses when floods strike in the areas, Figure 4.14.

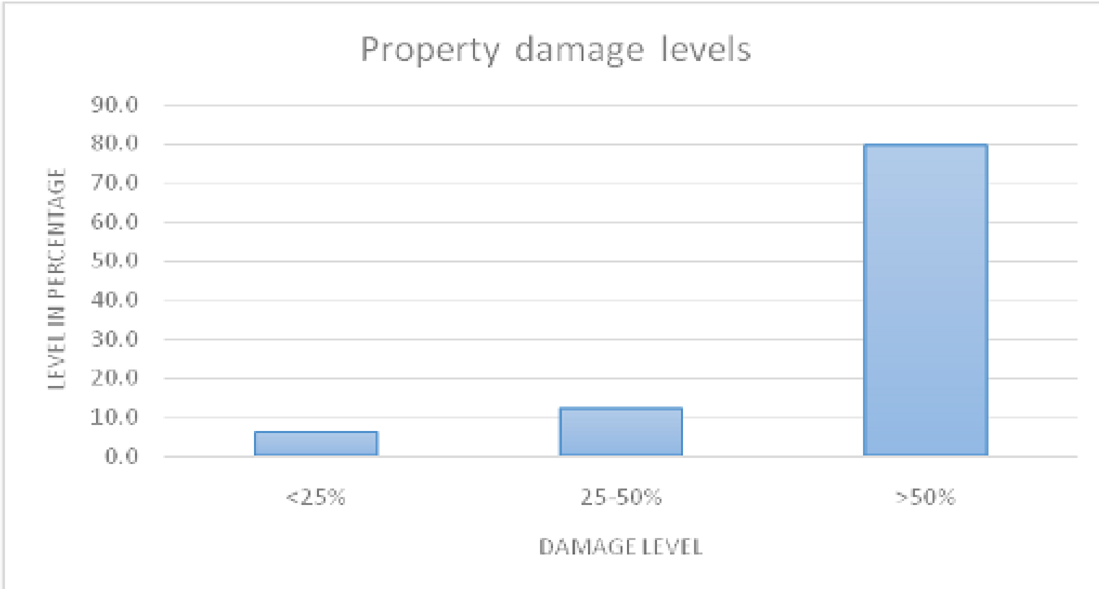

Figure 4.14: Property damage levels

Despite the destructions and damages in place, the community through the respondents sampled indicated that there were no measures they had put as a community to curb flooding, this was represented by 65.43%. On the other hand, 34.57% indicated that they had put some measures or multiple measures were in place to curb flooding.

The measures included canals, channels dug along the river, clearing of swamps to direct water onto the lake, construction of river dykes, terracing, sand bags aligned along the rivers to create a manmade levees and there had been formulated plans on how to respond to emergency and move to flood safe zones when the disaster strikes (Table 4.11).

Table 4.11: Local flood control measures

Measure type	Frequency	%
No measures	106	65.43
Dykes	4	2.47
Canals	7	4.32
Terracing	30	18.52
River Channels	2	1.23
Clearance of swampy and bushes	2	1.23
Sand breaking	4	2.47
Planting trees	4	2.47
Combined types	3	1.85
Totals	**162**	**100.00**

4.6 Reasons why Inhabitants Continue to Occupy Flood Risk Zone

The study sought to establish the reason why the respondents at risk to flooding continue to inhabit the flood risk zone despite the dangers of flooding. The findings show that the respondents in the area are still keen to stay on the area due to societal factors. The key factor as shown in the figure 4.15 below can be interpreted to show that the key reasons why they are still on the area is majorly social. Social factors are considered very important to them while the least factor that can hold them on site is economic factor.

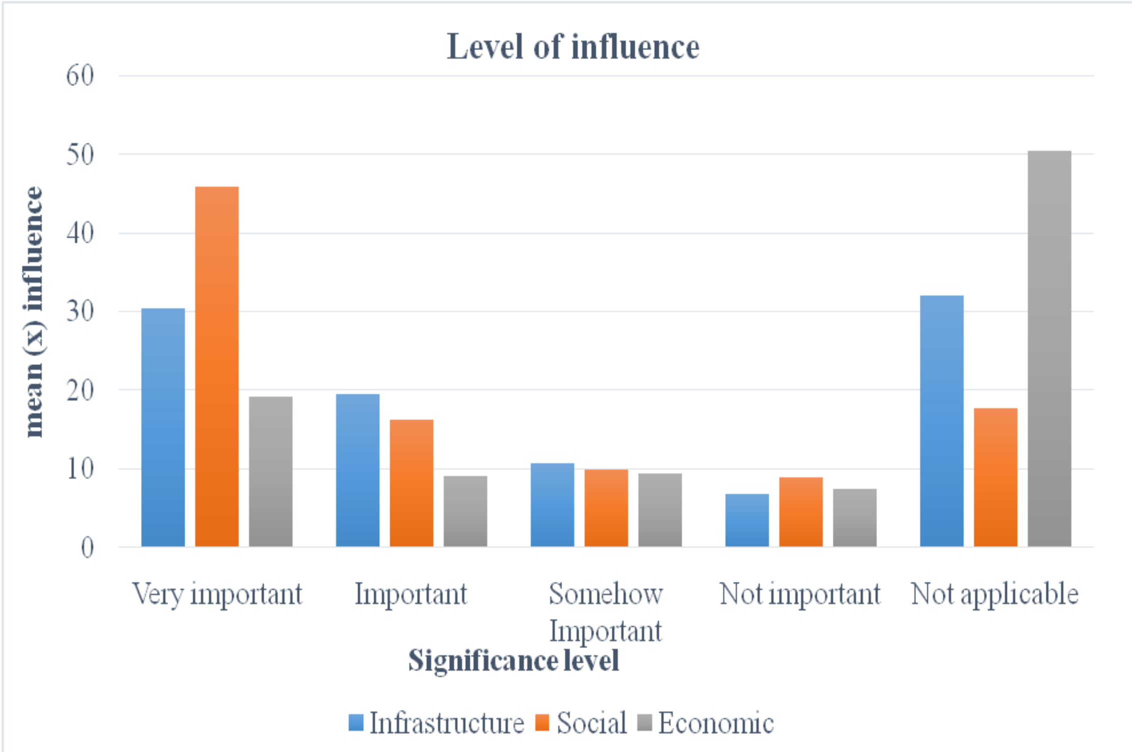

Figure 4.15: Level of community influence

The research sought to establish why the rigidity in change basing on economic, social and infrastructure as discussed below. The respondents despite the more than 50% of destruction of their property by floods still live in the area which is at risk and has seen a number of people lose their lives directly or indirectly through diseases or drowning.

Table 4.12: Factors for resistance to change

Level of significance	Very important	Important	Somehow Important	Not important	Not applicable	Level of significance	Very important	Important	Somehow Important	Not important	Not applicable
Land is Fertile	59.9	13.0	19.1	3.1	4.3	Near shopping centre	23.5	17.9	6.8	4.3	46.9
Inheritance	70.4	9.3	4.9	4.3	10.5	Near Water	32.7	15.4	4.9	6.2	40.1
Only Land	71.0	18.5	2.5	2.5	4.9	Only Bridge	34.0	13.0	1.9	1.9	48.8
No other school	59.9	34.0	3.7	1.9	0.0	Convenient Bridge	13.6	8.0	9.9	9.9	58.0
Best School	37.7	38.3	21.6	.6	1.2	Only Road	62.3	32.7	3.1	1.2	0.0
Near School	63.6	29.0	6.2	.6	0.0	Only Accessible Road	32.1	39.5	14.8	4.9	8.0
Food Security	23.5	22.2	36.4	13.0	4.3	Livestock	45.7	13.6	.6	3.7	35.8
School undamaged by Floods	39.5	16.0	10.5	8.0	25.3	Livestock for ploughing	3.1	1.2	1.2	12.3	81.5
Feeding program	3.1	20.4	21.0	16.7	38.3	Grazing Fields	9.3	25.9	18.5	6.2	0.0
No other Hospital	54.3	30.2	4.3	3.1	7.4	Livestock source of income	17.9	18.5	7.4	9.3	0.0

Level of significance	Very important	Important	Somehow Important	Not important	Not applicable	Level of significance	Very important	Important	Somehow Important	Not important	Not applicable
Good Hospital	7.4	10.5	39.5	20.4	21.6	Own Farm Machinery	3.7	.6	.6	2.5	92.6
Residential Houses Available	43.2	9.9	.6	1.9	43.8	Use of machinery for ploughing	6.2	3.7	1.2	1.9	87.0
Own Crops on farm	72.8	13.0	1.9	6.8	5.6	Own a Home	82.7	7.4	.6	1.2	8.0
Availability of surplus	21.0	24.1	8.0	14.2	32.7	Permanent Home	77.2	10.5	.6	11.7	0.0
Crop yield is adequate	6.2	4.3	28.4	29.6	31.5	Donated House	6.2	1.2	.6	4.9	87.0
Danger to lives	73.5	11.1	4.9	4.3	6.2	Availability of Tenants	1.9	1.2	.6	1.9	94.4
Waterborne diseases	73.5	11.1	4.9	4.3	6.2	Availability of Non-Farm Income	28.4	16.7	16.7	9.9	28.4
Interruption to social life	82.1	9.9	3.7	2.5	1.9	Inadequate sanitation	48.1	11.7	2.5	4.3	33.3
Loss of life in drowning	40.7	16.0	16.0	21.6	5.6	Earth/Mud houses	63.0	16.0	3.7	6.2	11.1
Safety of older people	37.7	25.9	12.3	19.8	4.3	Household income adequate	4.9	8.6	34.6	26.5	25.3

Level of significance	Very important	Important	Somehow Important	Not important	Not applicable	Level of significance	Very important	Important	Somehow Important	Not important	Not applicable
Deaths through flooding	50.6	29.0	5.6	11.7	3.1	Food shortage	45.1	19.8	21.0	8.0	6.2
Water is sustainable	35.2	25.9	25.3	4.3	9.3	Adequate Food	6.8	4.9	22.8	20.4	45.1
Good management of water	12.3	10.5	27.2	13.6	36.4	Granaries affected by floods	31.5	11.7	4.3	25.9	26.5
Availability of treated water	25.3	17.9	13.6	9.9	33.3	Fishing is risky	40.7	4.9	.6	2.5	51.2
Water Pollution	80.2	13.6	1.9	3.7	.6	Fish culture	42.0	5.6	.6	1.9	50.0
Water use conflict	21.6	4.3	9.3	20.4	44.4	Stability of Income from Fish	18.5	8.6	14.2	8.0	50.6

4.6.1 Social factors

Societal factors are the cultural attributes that define a community. These factors are known to be key in determining community livelihoods and their way of living. Land ownership, housing, sanitation, crop types and livestock keeping were considered social aspects of a community. The figure 4.16 shows the respondent's attachment to societal factors and 63% reported that social factors are so important and they will not move because of social factors.

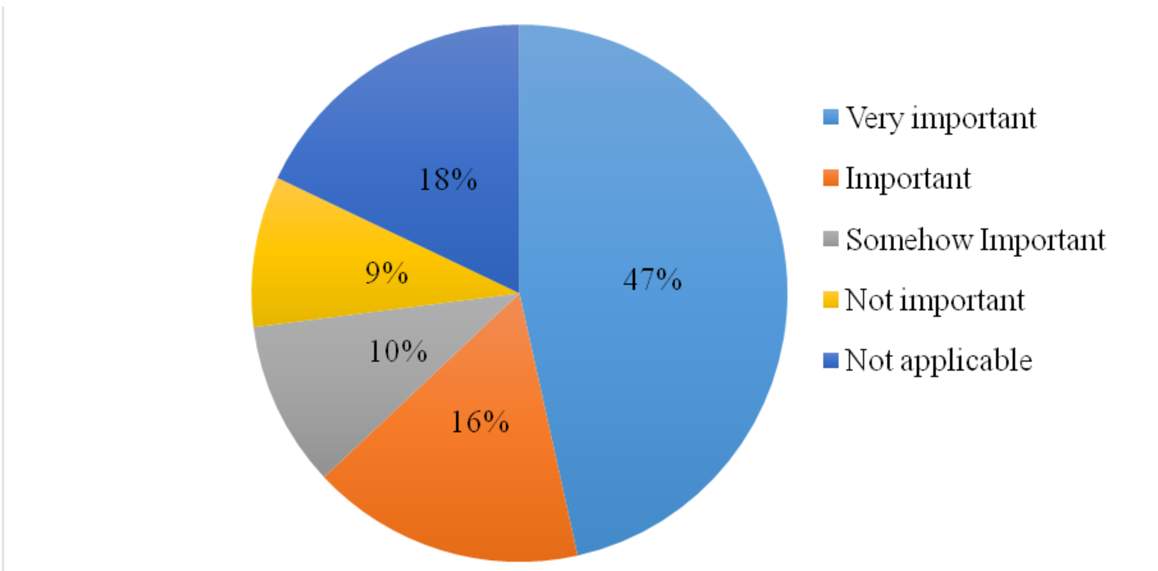

Figure 4.16: Social factors determinants

It was found out that 47% of the respondents reported that social factors was a very important factor to their movement from their current location, (Figure 4.17). The remaining respondents, 18%, said that social factors did not matter and they would therefore move despite of these factors in the area.

Most of the residents reported that they would not move from the area because they own a home. This was reported by 82.7% of the total social factors respondents. Land ownership was also key and 70.4% and 71% wouldn’t move despite the ragging floods due to inheritance of land which they regarded as the only land. Figure 4.18 illustrates the degree of importance attached to societal factors.

Crops ownership on land also came as key factors on why the residents would not move from the area with 72.8% reporting that the crops on the farms were very important while 80.2% said they would move because of the pollution by sediments and water quality in the rivers.

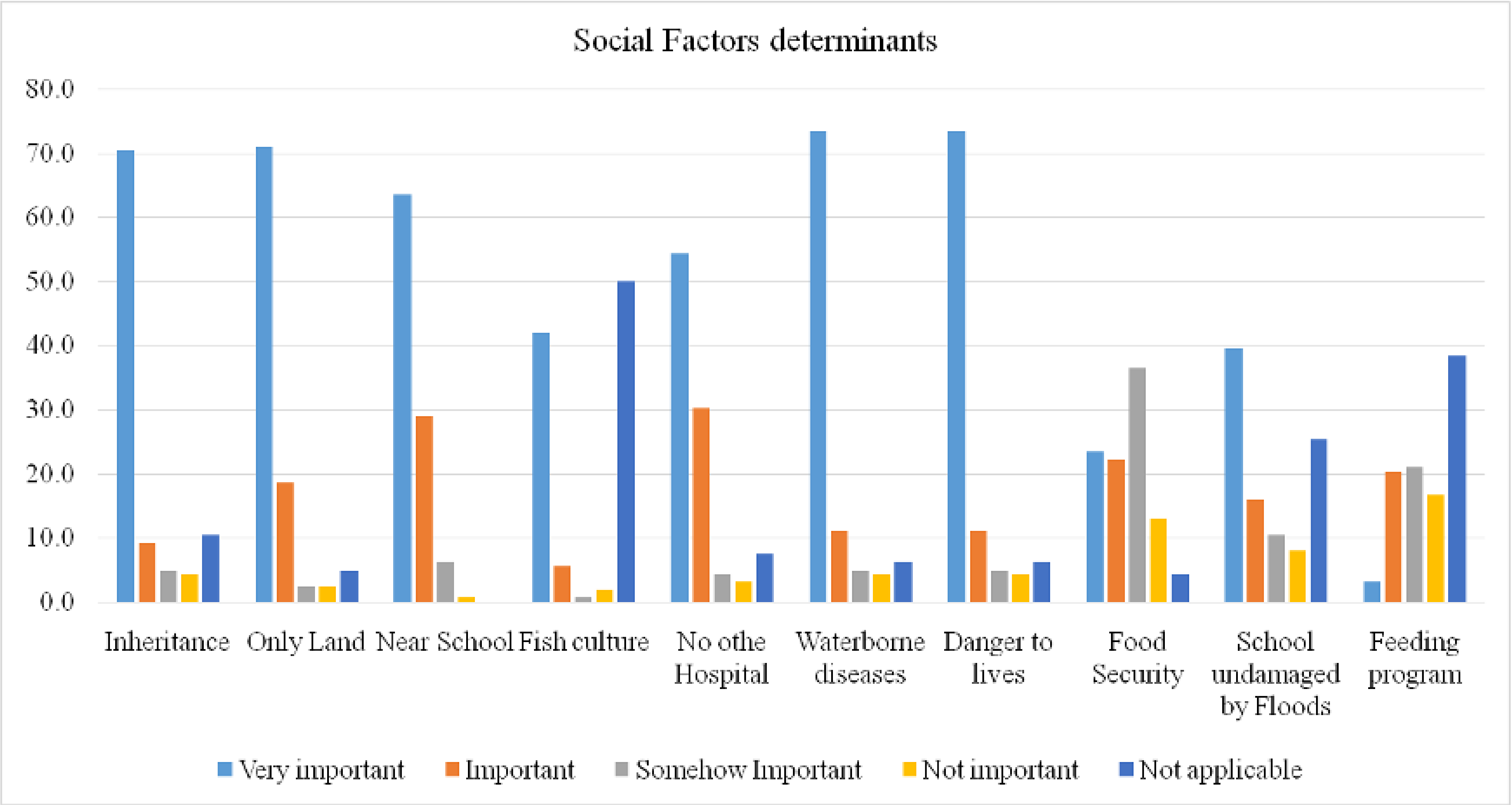

Figure 4.17: Other Social factors determinants

4.6.2 Economic factors

These are the economic aspect of why the respondents did not want to move from their current residents. The study established that the economic factors that influence the household and which are at frequent risk of flooding were those who deemed economic activity as not applicable to why they should move. Around 53% said that economic activity in the area is not of any significance while 8% said not so important but they could move out due to other factors.

The major attached economic factor that make them not move was soil fertility, 59.9% (of the economic factors respondents) said that the soil fertility in the place was so important and they would not move at any given time unless provided with equal fertile area.

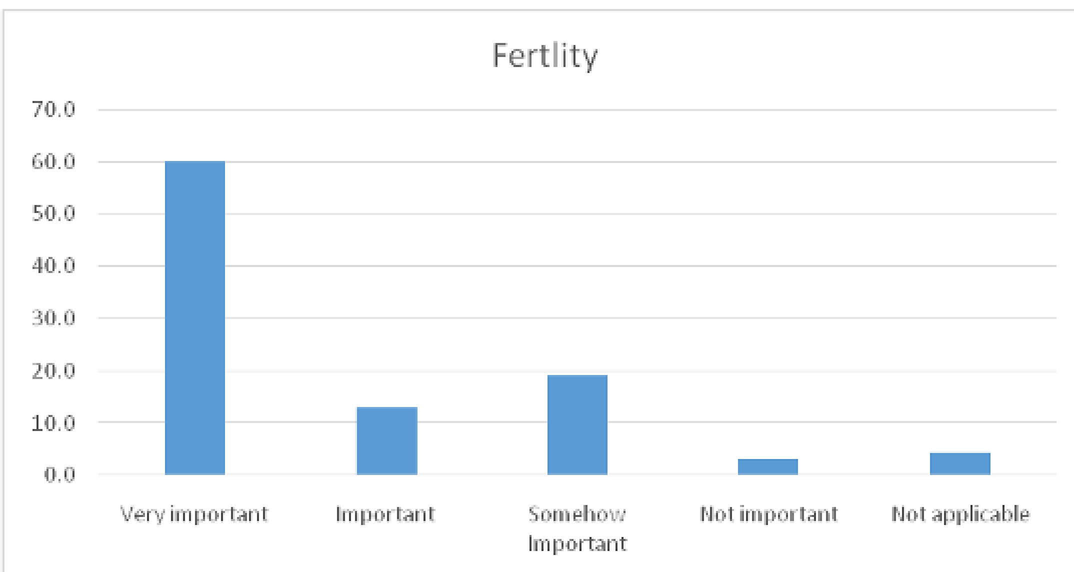

Figure 4.18: Fertility chart

The proximity to shopping centre was also a key economic factor, 23.5% said that they would not move because of proximal location to market. Availability of non-farm income was very important to 28.4% of the respondents, these included engaging in fishing, offering services like bodaboda, teaching, tailoring and shop keeping Table 4.12.

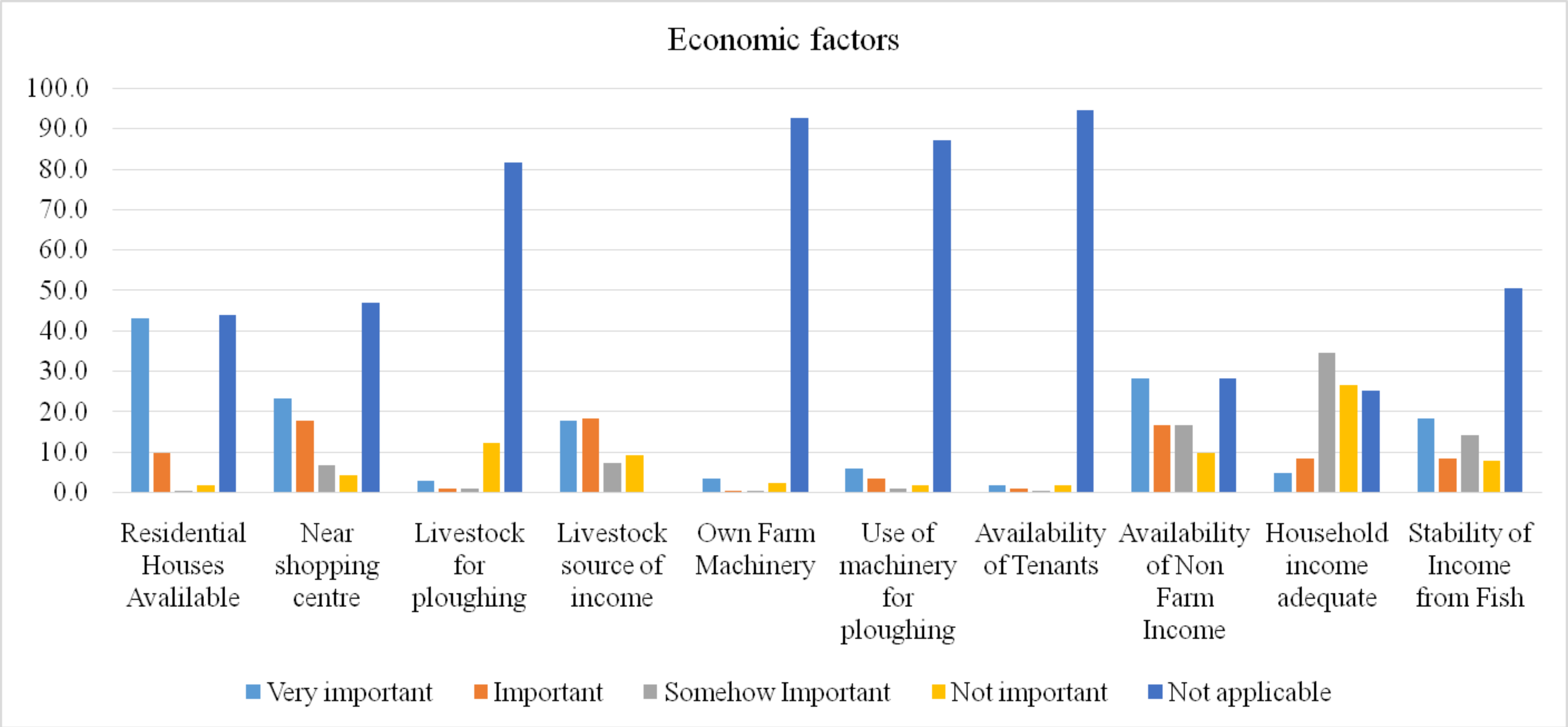

Figure 4.19: Economic activities

4.6.3 Infrastructure

Infrastructure is the key to spurring development and also in times of emergency it is the key to rescue service. The research sought to establish the influence of infrastructure on the household's attachment to the flood prone zones.

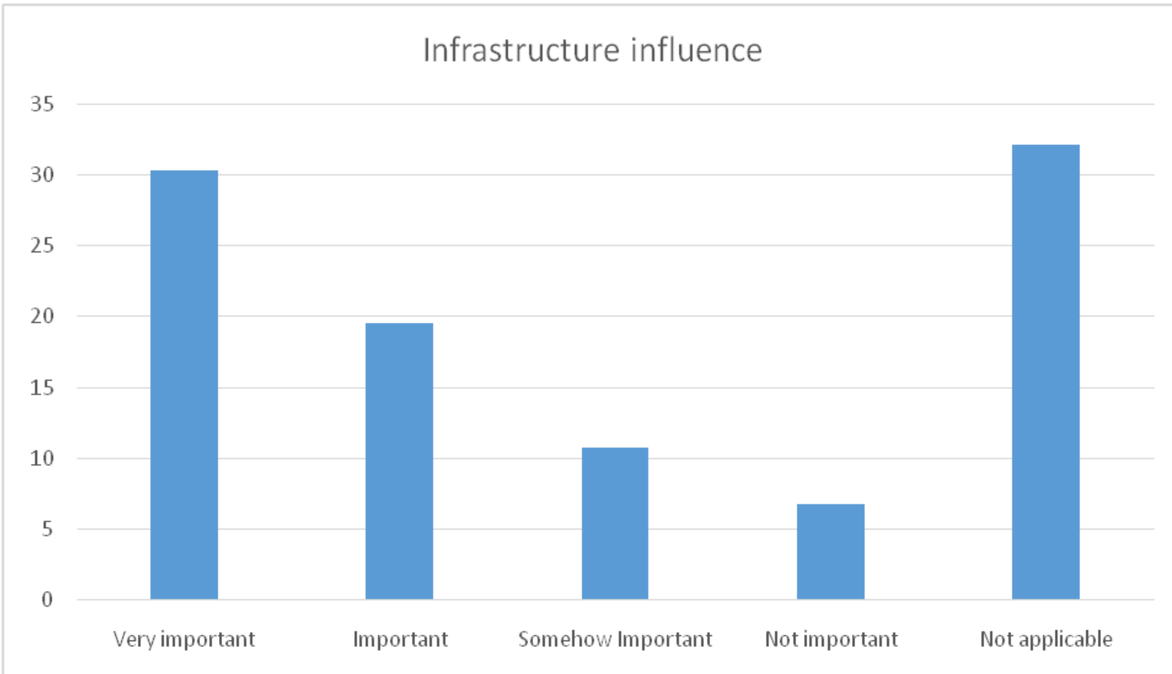

Figure 4.20: Infrastructure influence

Infrastructure had no strong determination in the respondents with 32% saying infrastructure was inconsequential and not applicable to their stay in the zone, though there was 30% which said infrastructure was key for their stay and they are not ready to move due to infrastructure, Table 4.12.

Roads, water and bridge was the most important aspect in infrastructure, 62.35% said the road was very important for their stay and daily commuting. About 34% of the respondents reported that the availability of bridges in their locality made them not to move as they stated that this was very important, bridge convenience also came under a sharp non consequential response with 58% saying the bridge was not applicable to their stay and they would move out of the place whether bridge was convenient or not. This could be related to the availability of waterways in most cases and during floods most of the bridges are submerged in waters which renders them not usable hence very inconvenient.

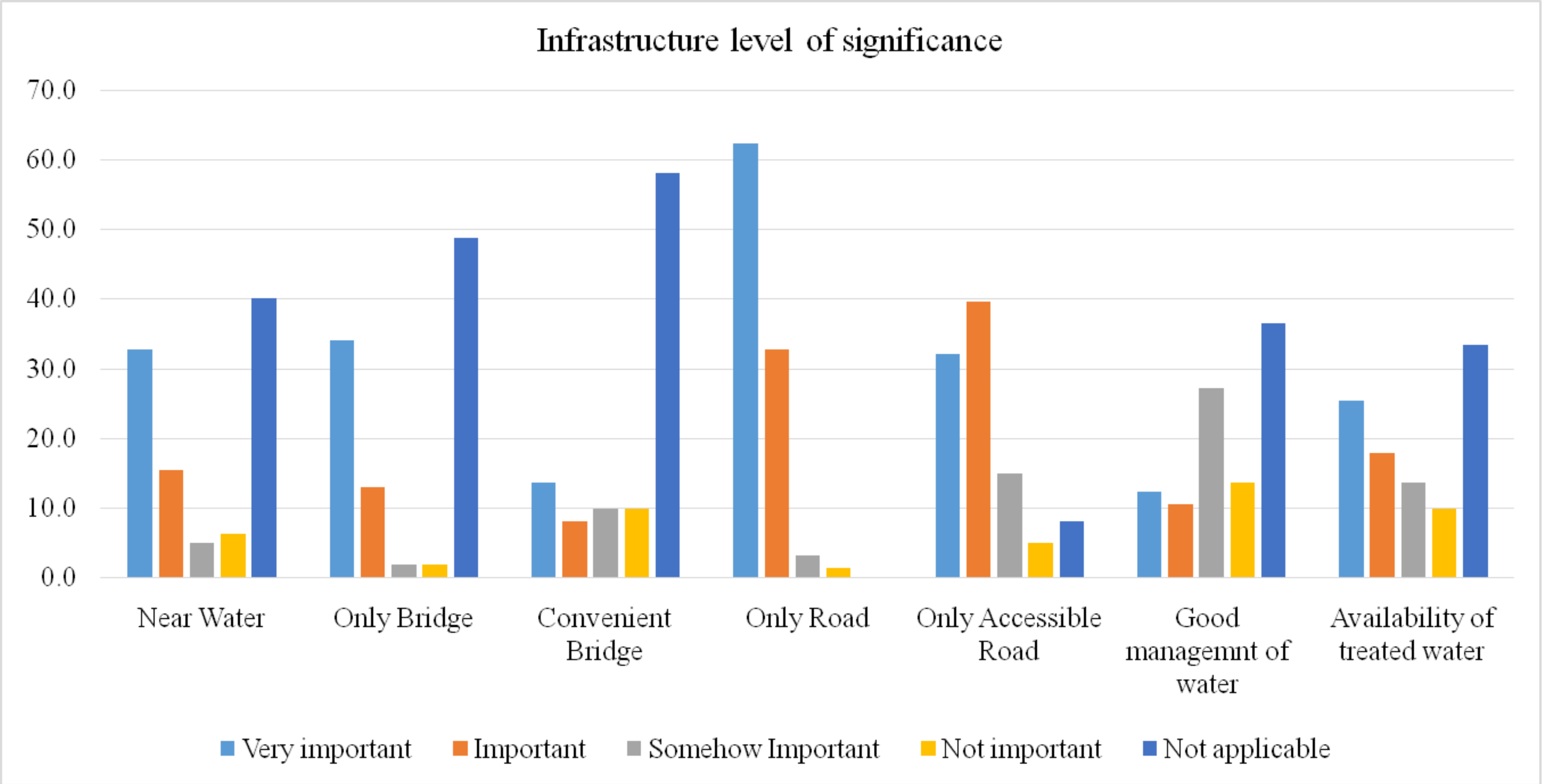

Figure 4.21: Infrastructure level of significance

CHAPTER FIVE: RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

The study arrives at the following recommendations based on the data obtained from the fieldwork.

5.2 Summary

This research adopted a cross sectional research design based on questionnaires, observation and ArcGis. It was carried out in the upper and lower zones of Budalangi sub-county. This included Bunyala west, Bunyala North, Bunyala East, Bunyala Central, Khajula and Bunyala South and a total of 162 households were sampled. The research instruments and equipment's used encompassed questionnaires, field checklists, cameras, Global Positioning devices, topographic maps, analysis software such as SPSS, and ArcGIS software. These sets of tools were used to collect both qualitative and quantitative data for data analysis.

The data collection procedure followed a defined path. The initial stage was data acquisition from SRTM, interviews with local key informants, acquisition of Landsat images and GPS information from the field, this was then preceded by preparation of the images using various softwares to come up with elements at risk. Identification and mapping of the flood prone areas was done by GIS analysis of Raster images acquired from Earth observatory. The peak flood stage was used to delineate the safe and risk zones. The peak stage value was determined through a combined procedure of purposive interview and recording of the elevation from the GPS.

Most of the residents in the area have lived for more than 50 years that is since their childhood and their parents were also living there. The major respondents were between 31-40 years of age comprising of 32.7%, 61.7% had at least acquired primary education and 78% of land in the plains was inherited from parents.

The major economic activities in the area are varied but the dominant ones are mixed agriculture (livestock keeping and crop cultivation) which accounted for 51.2% other activities included crop cultivation only, fishing, livestock keeping only and sand harvesting in their order of dominance.

The land cover in the area was majorly farmland accounting for 36% and it is on the North of the study area which is on a higher ground while riverine vegetation and swamp accounted for 34% and it was on the border of L. Victoria and along River Nzoia and other rivers, the other land uses were build up areas which included roads and residential buildings which was 21%.

Determining flood risk areas was key goal for the research and it was established that 50% of the resident faced floods very often while 3% do not experience floods in their farms. Floods was reported by 70% of the respondents to cause more than 50% damage to their property. The flood risk zones included 39% of the total land cover which is $76.1km^2$ while the safe zones were 61% or $119.7km^2$.The major flood zones were along river Nzoia and any zone lying below 1143m ASL and most of the regions in the South areas bordering L Victoria. Absolute flood zones was determined and it was observed that zones under 1143m and don't either touch the flood rivers was 68.58 km^2 the $6.5km^2$ is a safe zone despite being below 1143m.

Economic activities at risk were determined and the research found that Farmland was at a greater risk affecting 19% or 12.5km^2 of farmland and 3.5km^2 of buildup areas. The study concludes that a large portion of the study areas is falling within the flood risk zone however, most inhabitants are unwilling to move because of social factors which included land acquisition, fertility and food security, and infrastructure which was of lesser concern.

5.3 Summary of the findings

The study major general objective was to undertake a flood risk mapping and assessment within Budalangi Sub-County and determine the socio-economic factors that make lowland inhabitants not to move despite the dangers of flooding, the major findings of the research based on the objective were found to be;

The study found out that 36% of the total land was under farmland which was represented by 69.9km^2 and the least was under aquatic and riverine vegetation covering 9%, this was important to determine the land uses at risk. To determine farmers who have experienced flooding on their farms, a questionnaire was rolled out and 96.9% of the respondents indicated that they've experienced flooding on their parcel of land only while 2.5% responded otherwise. Further, of the 96.9% who experience floods 50% responded that they regularly experience flooding.

In flood risk zones demarcation, it was observed that there was 61% of flood safe zones in the areas while 39% were flood prone zones which were represented by 76. 16km^2 and safe zones was represented by 119.77km^2 a total land cover. This safe zones were majorly on higher areas of Mundere, Budalangi High school and Bukangasi. Activities at a high risk of destruction by flooding was found out to be 19% of farmlands and 55 of buildup areas were at a risk of destruction by floods. These were homes, schools and churches in the areas with farms containing food products. This destruction in figures accounted for 12km^2 of farmland and 3.5km^2 of buildup areas were at a greater risk of destruction by floods.

The study sought to establish the reason why the respondents at risk to flooding continue to go back to the flood risk zone. The findings show that the respondents in the area are still keen to stay on the area due to socio-cultural factors such as land ownership, housing, sanitation, crop types and livestock keeping. The respondent's attachment to social factors was 63%, which reported social factors to be important and they will not move because of social factors. The key social factors that gained major importance was inherited land, only land and nearby school.

5.4 Conclusion

This study concludes that significant distinctions could be made between area at high risk of flooding and safe areas. The study established that the lower regions of the study area were more prone to floods than the upper sides and there were more vegetation cover on the lower zones than the upper zones, this was observable via satellite images.

5.5 Recommendations

Based on the first research objective- map flood risk zones within Budalangi Sub-county using SRTM data- the study makes the following recommendations;

i. NGOS and county government to use information on flood risk mapping to determine and locate safe zones for ease of evacuation and safe more lives. This could also be used in valuation on community's attachment to societal matters and how they can be moved.

ii. All zones below 1143m ASL should be evacuated in the event of rain upstream, this are the zones majorly prone to floods apart from those not in direct contact with the river plains.

iii. The areas of Bukangasi and Budalangi High School should be marked as rescue centre since they are within flood zone areas but on higher grounds.

Based on the second objective of the study- to determine the land use elements at risk from both land use/cover and flood risk maps-the study makes the following recommendations;

i. To secure the 19% of farmlands, new zonation and rural development plans be drawn to 55% of buildup that includes roads, homes, bridges, schools, hospitals and churches should be relocated to the nearby higher zones that's above 1144m ASL.

ii. The research also advises that zones along river Nzoia between 100m should be left vacant for riverine vegetation and act as natural river levees. This will aid in rising river banks beyond the 1143m threshold for floods to break the bank along the River

The third objective of the study was- to analyze the socio-economic factors that motivate those at flood risk zones to continue occupying the areas despite ragging floods and the study puts forward the following recommendations;

i. Since social factors are the major reason why residents don't want to leave, the community should be sensitized on the importance of life and be advised to live on higher grounds and perform their cultivation (only for subsistence use) at the farmers in the lower zones.

ii. There should be proper sensitization on rain cycles and the residents be advised to plant their crops earlier and use irrigation since 29% of them depend on crops from food crop and 51.2% are into mixed cropping.

5.6 Recommendation for Further studies

Infrastructure is a major boost to both Social and economic pillars of a community. It is the link between communities and communities and opens up communities to the entire global village market. It is the key theme for vision 2030 in Kenya and also MDGs agenda for sustainable development. However, in Budalangi there is a missing link between infrastructure and its importance. The community has not embraced the need for infrastructure and in some cases they reported that bridges and roads were inconsequential and rated not important and whether they were there or not they won't affect their stay in the flood prone zone. The study therefore opens up for a study on the missing link between the Budalangi infrastructure and community perception on the same.

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APPENDICES

Appendix I: Sample Questionnaire

Flood risk mapping and factors that motivate the affected community to continue living in the flood risk zones in Budalangi Sub-County, Busia County, Kenya

PREAMBLE

This questionnaire is meant to collect information on **Flood Risk Mapping and Assessment in Budalangi Sub County.** This information is being sought solely for academic purposes and will be treated with strict confidence. Kindly answer the questions by writing a brief statement or ticking the boxes provided as applicable.

GPS Coordinates:	Waypoint		Longitude		Latitude		Elevation	

A: RESPONDENT IDENTIFICATION

1. Date ___________________ Name of the respondent (optional): _______________
2. Sub-Location: ________________________ Village ___________________________
3. Duration of stay in this region (state in years)?

Last 5 years ☐ Last 10 years ☐ Last 20 years ☐ Over 20 years ☐

B. DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

1. Age category: 10-17 years ☐ 18- 30years ☐ 31-40 years ☐ 41-60 years ☐ Over 60years ☐

2. Marital status: Married ☐ Single ☐ widowed ☐ divorced/separated ☐

Sex: Male ☐ Female ☐

3. Highest Educational level: illiterate ☐ Primary ☐ Secondary ☐

Middle level College ☐ University ☐

C. ECONOMIC

1. What is the main economic activity you are engaged in?

Fishing ☐ Sand harvesting ☐ Livestock keeping ☐ Logging ☐

Crop cultivation ☐ Mixed farming ☐ Forestry ☐

Other, specify____

2. Apart from this main economic activity, what else are you engaged in?

Fishing ☐ Sand harvesting ☐ Livestock keeping ☐ Logging ☐

Crop cultivation ☐ Mixed farming ☐ Forestry ☐

Other, specify____

LAND OWNERSHIP

1. Do you own the land you are settled in? Yes ☐ no ☐

2. If yes, how did you acquire it?

Inherited ☐ Purchased ☐ Gift ☐ Other, Specify________________

3. If you don't own the land how have you accessed it?

Squatting ☐ Family land ☐

4. What is the approximate size of the land?

   Less than 1 acre ☐ 1-2 acres ☐ 2-5 acres ☐ More than 5 acres ☐

   Unknown ☐

5. What is the main activity you carry out in your land?

   Cropping ☐ Agro-forestry ☐ Forestry ☐ Mixed farming ☐

   Livestock keeping ☐ Houses for rentals ☐ Other, specify ___________

D. AREA RESIDENTS' PERCEPTION OF SOCIO-ECONOMIC COSTS OF INHABITING FLOOD PRONE AREA.

1. Does your land or part of your premise flood? Yes ☐ No ☐
2. If yes, how often? ☐Very often ☐ Often ☐ Sometimes ☐

   Occasionally ☐ Never ☐

3. What is the percentage property damage to your premise?

   <25% ☐ 25-50% ☐ >50% ☐

4. Do you have local measures to counter floods? Yes ☐no ☐

   If yes, what are they? ____

5. What are some of the local soil conservation measures that have been put in place to limit siltation? ____

6. How would you rate these measures?

   Very successful ☐ Successful ☐ Fair ☐ Weak ☐

7. If your land or part of your premise or facility you use get flooded occasionally, sometimes, often, or very often
   Rate the reasons why you continue to inhabit or settle or use the land or facility despite the floods.

	Very important	**Important**	**Somehow important**	**Not important**	**Not applicable**
My land is very fertile					
I inherited the land so culturally I can't leave					
It is the only piece of land I have					
The school is the only one in the area					
The school is the best performing in the area					
The school is the nearest					
Hunger is a barrier to school participation					
Classrooms are not damaged during rains					
High school enrollment					
The school has a feeding Programme					
HEALTH					
The hospital is the only one in the area					
The hospital is the best equipped with					

good health officials					
RESIDENTIAL					
The residential house is the most affordable					
The residential house is the only one					
The residential house is near to my shopping centre					
It is located near to water source					
BRIDGE AND ROAD					
The bridge is the only one					
The bridge is convenience to use					
The road is the only one					
The road is accessible					
LIVESTOCK					
I own the livestock					
I use the livestock in preparing the land					
I feed the livestock on my piece of land					
I sell the livestock occasionally					
TRACTOR					
I own a tractor and I care for it					
I use it to plough the land					

HOUSE AND RENTAL					
I own this house					
I have rented the house I live in					
The house is near to the source of water					
I planned and designed my own house					
The house was constructed by a donor/a hired contractor					
The tenants don't pay the rent					
The tenants pay the rent in time					
The household does not have non-farm income activity					
The house does not have its own latrine/toilet					
The floor of the house is made of mud/earth/cow dung					
The annual household income is enough to sustain the family					
The household experiences food shortage					
FOOD SECURITY					
There is enough					

food in the stores for the entire household					
The granaries are always affected by floods/are swept by the floods					
The granary is made up of weak materials					
FISHING					
Fishing is a high risk business					
Fishing is a cultural activity					
Fishing is a serious economic activity					
FARM CROPS					
The crops on the farm are mine					
I sell the surplus to generate income					
The crops on the farm are not mine					
I leased the farm to get money for school/hospital bills					
The crop yield is enough for the family for a year					
RISK TO LIVES					
People's lives is at risk					
The residents of the area are safe from flooding					
The human settlement is free from flooding					

The human settlement floods occasionally					
The social life is normally interrupted					
DISEASES					
The spread of HIV/AIDS in refugee camps is high					
There is normally spread of malaria, bilharzia and cholera after floods					
Most of the family members drown during floods					
Most of the old people get trapped during floods					
The deaths of women, children and the old is high during floods					
There is sustainable use of water resources					
There is pressures and barriers on sustainable use of water					
There is management of water in the markets					
Waste water is treated and purified					

There is water pollution resulting from contaminated land, landfills and sediments					
The area has water use conflicts					

F. STRATEGIES FOR FLOOD MANAGEMENT

Which mitigation measures can be adopted in the catchment areas to reduce flooding in the plains?

____

Appendix II: Observation Checklist

1. Current land use and land cover.

SITE	TYPE OF DEBRIS	GPS LOCATION	m.a.s.l (elevation)

2. Economic activities.

SITE	TYPE OF DEBRIS	GPS LOCATION	m.a.s.l (elevation)

3. Flood control measures.

LOCATION	FLOOD CONTROL STRUCTURES	GPS LOCATION	FUNCTIONALITY

Appendix III: Research Authorization

NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349, 310571, 2219420
Fax: +254-20-318245, 318249
Email: secretary@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No. **NACOSTI/P/15/26844/7955**

Date:
9th December, 2015

Immaculate Abisacki Likuyi
Moi University
P.O. Box 3900-30100
ELDORET.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Flood risk mapping and assessment in Budalangi Sub-County, Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Busia County** for a period ending **25th October, 2016.**

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

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

DR. S. K. LANGAT, OGW
FOR: DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Busia County.

The County Director of Education
Busia County.

THIS IS TO CERTIFY THAT:
MS. IMMACULATE ABISACKI LIKUYI
of MOI UNIVERSITY, 661-50100
Kakamega, has been permitted to conduct research in *Busia* County

on the topic: *FLOOD RISK MAPPING AND ASSESSMENT IN BUDALANGI SUB-COUNTY, KENYA*

for the period ending:
25th October, 2016

Permit No : NACOSTI/P/15/26844/7955
Date Of Issue : 9th December, 2015
Fee Recieved :Ksh 1,000

……………………………
Applicant's Signature

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

CONDITIONS

1. You must report to the County Commissioner and the County Education Officer of the area before embarking on your research. Failure to do that may lead to the cancellation of your permit
2. Government Officers will not be interviewed without prior appointment.
3. No questionnaire will be used unless it has been approved.
4. Excavation, filming and collection of biological specimens are subject to further permission from the relevant Government Ministries.
5. You are required to submit at least two(2) hard copies and one(1) soft copy of your final report.
6. The Government of Kenya reserves the right to modify the conditions of this permit including its cancellation without notice

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No. A 7460

CONDITIONS: see back page