INVESTIGATING EFFECTS AND MANAGEMENT OF FLASH FLOODS IN MARIGAT SUB-COUNTY, BARINGO COUNTY, KENYA

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DECLARATION

This research project is my original work and to the best of my knowledge has not been submitted or presented for examination in any other institution either in part or as a whole.

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RECOMMENDATION

This project has been submitted for examination with our recommendation as University supervisors

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DEDICATION

I dedicate this work to my wife, children, colleagues at Kabarak University, and friends for their support and encouragement.

ABSTRACT

Flash flood is a natural disaster that occurs due to the sudden onset of rainfall that causes runoff waters from high altitude areas to low altitude area. The purpose of the study was to investigate the effects and management of flash floods in Marigat Sub-County. The study used a descriptive research design. The target population of the study area was 24,893 households. Purposive sampling and stratified random sampling methods were used to select three locations affected by flash floods. These were Ilng'arua, Ng'ambo and Salabani. The locations had a population of 3168 households, from which a sample size of 355 was obtained. The study relied on both primary and secondary data. The questionnaires, key informants interview and observations were used to collect data. SPSS version 23 was used in the analysis of the data. This study adopted percolation theory in determining the effects and management of flash floods. The reliability of the instruments was through subjecting piloted data to Cronbach's analysis and the causes of flash floods was 0.70 alpha level, effects of flash floods was 0.73 alpha level and mitigations measures of flash floods was 0.71 alpha level proving a good instrument because any value less than 0.7 is not acceptable. The study found that; causes of flash floods were, Clearing of vegetation, climate change, topography, unsustainable farming practices, overstocking and siltation. 53% of the respondents inferred that, clearing vegetation is the main cause of flash floods. Further more, the study found that flash floods resulted in soil erosion. The recommended mitigation measures of flash floods in Marigat Sub-County were; cash transfers, humanitarian aids, building of bridges, and traditional early warning. The conclusions of the study was the local community were knowledgeable of the causes of flash floods but do not have resilience skills to predict and prevent flash floods. Additionally, the study held that flash floods have contributed to the increased poverty level in the study area. Lastly, the mitigation measures are limited, leading to frequent flash floods occurance with adverse effects. Recommendations are policy review and their implementations. The findings and recommedations of the study are beneficial to Baringo County and the national Kenyan government for management of flash floods and the achievement of sustainable development goals which directly benefits the residents of Marigat sub-county.

Keywords: Marigat, Flash floods, Management.

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ABBREVIATIONS AND ACRONYMS

AMREF	African medical & research foundation.
CARE	Cooperative for assistant & Relief.
FFG	Flash flood guidance.
FGD	Focus group discussion.
Freq.	Frequency.
HHH.	Household heads..
IPCC	Intergovernmental panel on climate change.
NACOSTI	National Commission of Science, Technology and Innovation.
NWS	National Weather Service.
RFC_S	River Forecast centres.
SPSS	Statistical Package for the Social Sciences.
UNDP.	United nation development programme
$WFO_{S.}$	Weather Forecast Stations.
%	Percentage.

OPERATIONAL DEFINITION OF TERMS

Causes : It is the reasons that makes some natural phenomena occur in the study area that include environmental features and there resources.

Climate change: It is the average climatic conditions of a place over a long period of time at least 30 years. This is a global phenomenon that largely impacts on ecosystems of the study environment. Marigat is an example of flash floods prone areas as the climate change effects are experienced.

Dependent variable: Refers to a varible that will only exist when another variable is present for example humanitarian aid presence relies on effects of flash floods to be present.

Effects: It refers to the output of the environmental problem resulting from flash flooding in the study area.

Effective rainfall: Is the residual rainfall caused by infiltration, detention, and evaporation has been subtracted from the actual rainfall; it is the portion of rainfall that becomes surface runoff at the catchment scale.

Flash floods: Are defined as a flood sudden onset, with the highest discharge peak, occurring in low-lying areas where water break the river banks reaching areas which are not always experienced.

Flash floods control: Refers to all methods used to reduce or prevent the detrimental effects of flood waters. The control methods include o divert flash-floods. Planting vegetation's for example trees to control the speed of the water, Terracing of hillsides to slow water movement and manmade channels.

Household heads: Refers to the heads of the family who are above eighteen years either male or female in the study area also refered as respondents.

Independent varaiable: This is a variable that exist on it own as long as an envionmenta problem arises for example destruction of social amenities.

Rainfall: in this study will refer to rain that falls in a place in a particular period. This facilitates understanding of the relationship of flash floods season compared to another rainy season in Marigat Sub-County.

Management : It it the methods that are used to address the environmental problem to create sustainability from from flash floods resulting to reduction the effects.

Marigat: It is the area under study, situated in Baringo County. It is located in latitude 0° 28' 21N and longitude 35° 59' 16E. Baringo is among the 47 counties in Kenya, situated in Rift Valley region.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

This chapter briefly highlights the background as well as the problem of the study. It further states the purpose of the study, the research objectives, research hypotheses, significance, the scope, limitations, and assumptions of the study.

1.2 Background to the study

Flash flood occurs when water inundates in a dry land, but it occurs in many ways, this includes hurricane scenario of water covering the land. Flash floods occur when the leeward side receives runoff from the side that had experienced convectional rainfall. Climate variability in warmer climates is reported by the Intergovernmental Panel on Climate Change (IPCC) 2007 to have an increased likelihood of flood occurrence. Weather-related disasters currently account for approximately 90% of natural disasters (M. C. Llasat et al., 2010). In flash flood-prone areas there is an evident increase of disaster-related losses aggravated by the increased population growth and economic assets (Kundzewicz et al., 2014). Approximately flood causes an annual $40 billion damage in the world (Webster, 2013). The United States records an annual loss of $8 billion per year in flood-related occurrences (Michel- Kerjan, Lemoyne de Forges, & Kunreuther, 2012). Millions of people have been killed in China due to flash floods (Ziegler, She, Tantasarin, Jachowski, & Wasson, 2012). In Europe early warning systems have been developed and improved through remote sensing and nowcasting that utilize mesoscales of up to 0-6 hours to predict the weather patterns and occurrences of flash floods, this is according to World Meteorological Organisation (Borga, Stoffel, Marchi, Marra, & Jakob, 2014).

In Africa, flash flooding has been experienced in different parts. News Africa, (2019), for instance, cites Mozambique with 5,756 homes and 141,325 people affected and Malawi, where 739,000 people were affected and from which 230,000 people were left without shelter in March 2019. According to a study done by Lukamba, (2010), Eastern Africa is leading in hydro-meteorological disasters (41%), followed by West Africa (24%) and North Africa (14%). The effect is depended on the intensity of the flash flood and the vulnerability of the areas as measured by its topographic and demographic features, the quantity and quality of the materials exposed. The anthropogenic interventions and the effectiveness of the prevention measures taken by the local authorities, the social effects of the flood differ.

Extreme flash floods are often experienced in the Mediterranean countries and tend to be greater in magnitude compared to the inner continental countries while they occasionally produce catastrophic damages.(M. Llasat et al., 2013). In Nigeria flash floods hazard risk analysis involving computing of flash flood hazard, vulnerability and dangers posed to the people have been to mitigate the disaster (Komolafe, Adegboyega, & Akinluyi, 2015).

In East Africa, Kenya is one of the country's that have experienced significant losses from flash flood occurrences. The most common being Budalangi flash floods, where they have become an annual event, claiming a number of lives and properties in Western Kenya, dykes have been used to prevent flash flooding and due to poor maintenance have led to failure (Okaka & Odhiambo, 2018). Nyando experienced flash floods in 2018 which greatly affected human life and environment (Okaka & Odhiambo, 2019). Moreover, in Tana River, flash floods have regularly occurred due to bursting of the banks of River Tana. In 2018, most families living along the Tana Delta were affected. The majority were evacuated by Red Cross humanitarian aid as a result of submerges of the house in flash flood water (Shukla, Husak, Way-Henthorne, Macharia, & Takeaways, 2016).

Marigat sub- County, especially Lake Baringo has since been identified as the most flash flood prone area in the Rift Valley since 2013 (Omondi et al., 2017). Approximately 2000 households were affected by the heavy rains that lead to an increase of the water level in Lake Baringo, homesteads and schools were equally affected (Deichsel, 2019). Almost five schools were submerged in Marigat making learning difficult for the better part of the first term of 2014. The livelihoods were exposed to the dangers of water-related diseases and the challenges of wild aquatic animals such as hippopotamuses and crocodiles invading villages (Deichsel, 2019). Marigat Sub-County has been affected by flash floods and this has led to the loss of lives, property and biodiversity. In most cases, the flash flood areas have been deserted, the social institutions have been disrupted and the entire economic function has been halted leading to Poverty. Despise all these challenges by flash floods occurring in Marigat, little information is available regarding the extent of flash flood effects and mitigation strategies. Because of lack of documentation in the study area, the research study was undertaken to establish the claim that flash floods occur and affect the target population. This study would address the problem of persistent effects of flash floods by providing appropriate mitigation strategies and encourage community members participate on meeting

this environmental challenges. The findings of the study would be beneficial to the Margat community in finding long term solutions in management of flash floods.

1.3 Statement of the Problem

The effects of weather changes due to climate have brought along adverse effects of flash floods in low-lying lands. Marigat in Baringo County is lowland that slopes towards Lake Baringo and during flash floods, people and animals die; property and food crops are destroyed. This affects economic generating units, premises, water sources, learning institutions and agricultural lands in Ilng'arua, Ng'ambo and Salabani locations. Despite frequent flash floods experienced annually in Marigat Sub-County and the negative impacts it has on the socioeconomic production, there is little documented information to guide the target population on the causes, effect and the management of flash floods. This research study therefore was undertaken to fill the knowledge gaps and formulate policies that would go along way in managemeng of flash floods in the study area. This study, therefore,sought to determine the causes and management of flash flood in Marigat Sub County, Kenya.

1.4 Purpose of the Study

This study aims at investigating the effects and management of flash floods in Marigat Sub-County, Kenya.

1.5 Objectives of the Study

1) To establish the causes of flash floods in Marigat Sub-County.
2) To determine perceived effects of flash floods in Marigat Sub-County
3) To determine mitigation strategies of management of flash floods in Marigat Sub-County.

1.6 Research Hypotheses

$H_{01:}$ There are no significant known causes of flash floods in Marigat Sub County.

H_{02}: There are no significant perceived effects of flash floods in Marigat Sub-County.

H_{03}: There are no significant mitigation strategies for the management of flash floods in Marigat Sub-County.

1.7 Justification of the Study

This study is in line with Sustainable development goal 13; that necessitates urgent actions to be taken to combat climate change and its impacts (Matyas & Pelling, 2015). Management

of natural disasters helps to improve the environmental values for money used in disaster management that provide a better environment for livelihood. Management strategies have been applied elsewhere that include mapping of areas prone to flash flood to enable estimation of the amount of water available within a rainy season (Forkuo, 2011). This has facilitated the loss of human lives, animals and protection of environmental resources that include habitats, food and beauty (Di Baldassarre et al., 2010). According to the economic pillar of the Kenya vision 2030, equity in terms of wealth creation is provided for all (Puzyreva & Roy, 2018). Data from this study would be beneficial to the county and national government and the disaster management unit in identifying potential management practices in order to prevent further losses resulting from flash floods.

1.8 Significance of the Study

The study aimed at assessing the causes, effects and management practises of flash floods in Marigat Sub-County. The findings of the study will further enable the local community to be aware of the expected disaster that might occur due to the varying climates during rainy season.Further poverty levels in the study area will reduce resulting to better management of the environmental problem that includes minimum crop destructions, reduction in cost of medical health and control soil ersion saving money the would be used in managing the environment. This would facilitate the government have an emergency preparedness plan in case of this problem.

1.9 Scope of the Study

The study was carried out in Marigat Sub County: Ilngarua, Ng'ambo and Salabani locations because they are lowlands affected by flash floods. This targeted household heads community. The study was conducted during the June –August 2019 after the approval of the proposal and permission from NACOSTI to carry out the study.

1.10 Limitations of the Study

The study was limited by the communication difficult in Iling'arua, Ng'ambo and Salabani locations in Marigat Sub-County which is a large area. The road network of the area was poor and the terrain is very difficult during rainy season due to flat plain water availability. Language barrier created a problem of understanding what the researcher wants from the

local and even interpretation of the language lead to different understanding from the expected outcome.

1.11 Assumptions of the Study

The research was conducted in Marigat Sub-County with the following assumptions

1. There were no known causes of flash floods.
2. There were no perceived effects of flash floods.
3. There were no mitigation strategies for the management of flash floods.
4. The respondents were willing to answer the questions and understand the information required for the study.

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CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a literature reviewed on the causes, effects and management practises of flash floods in the world, Africa, Kenya and finally Marigat Sub-County. The chapter also describes the theoretical and conceptual framework for the project study.

2.2 Flash floods

Flash flood is a natural phenomenon arising from the sudden release of water due to heavy rainfall, or the sudden release of impounded water in a dam occasioned by a landslide, ice jam in a river or because of a glacier lake outburst (Kundzewicz, Hirabayashi, &Kanae, 2010). A major difference between a flash flood and a river line flood is the short basin response to rainfall, which allows for very short lead time for detection, forecast and warning (Deichsel, 2019). On the contrary, larger river flash floods have longer lead time raging several days in some circumstances. Therefore, the management of flash flood requires specialized measures tailored to their characteristics (Gaume & Borga, 2008a). When rainfall events cause Flash floods, it is highly a hydro meteorological occurrence. Even though the amount of rainfall is significant in flash flood intensity consideration, ground service characteristics is a factor to reckon with.

Marigat is a lowland and the rivers that supply water to Lake Baringo are Endao,Perkera and Molo. When these rivers approach Marigat the beds come up due to increased siltation from eroded farms. This makes the water beds rise to the surface of the ground and when it rains the river banks burst; making the flash floods to occur (Deichsel, 2019). As this disaster occurs, the local community may not anticipate extensive damages to the lives and environment.

2.3 Causes of flash floods Occurrence

Flash floods are a natural disaster whose causes are many depending on the geography of a place among many other factors.

2.3.1 Intense Convective Rainfall

These are types of flash floods resulting from intense conventional rainfall. (Rasmussen, Zuluaga, & HouzeJr, 2014). Heavy rain events are generally short-lived from a few minutes

to a few hours (Deichsel, 2019), but can be very intense such as 100 mm (or 100 Litres per square meter) in the span of a few hours or even less than an hour. Some hydrologic characteristics to be considered include the soil moisture (fraction of saturation), soil depth, soil permeability (can be affected by wildfires, frozen ground or compaction of the soil), land use/land cover (such as amount of vegetation, urbanization), size of the basin (most flash floods occur in small basins (less than 100 – 200 km^2 in size), and basin slope (steep slopes generally result in greater runoff potential from rainfall events)(Watson, 2012). Flash floods occur even under the right conditions such as unsaturated or dry soils; notwithstanding draught conditions. Recently, flash floods have been reported in desert areas where the flood wave exceeds the infiltration capacity of the dry soils (Alexandrov, Laronne, & Reid, 2007). Under these circumstances, rainfall that overwhelms water infiltration capacity of the soil can cause overland flow. Flash floods, generally, are common in mountainous desert regions especially in steep terrain and high surface runoff rated areas where severe convective rainfall is common (Nguyen, Thorstensen, Sorooshian, Hsu, & AghaKouchak, 2015). moreover, topography factors are indications for susceptibility to flash-flood (Wahid, Madden, Khalaf, & Fathy, 2016).

2.3.2 Land topography

Another cause of flash floods – particularly in mountainous terrain outside the tropics– can be rain on snow events (Merz, & Blöschl, 2003). If there is heavy snow on the ground, a sudden rise in temperature along with substantial rainfall can cause rapid snowmelt and consequently the formation of snow. Melt-induced flash flood. A flash flood may also result from a failure of dams, embankments, or other hydraulic infrastructures (Sene, 2016a). Other causes might be glacier lake outbursts or outbursts of landslide dams. In 2008 there were more than 30 landslide dams caused by the 2008 Sichuan earthquake in China. In southern Sichuan, people living downstream of the landslide dams were forced to evacuate because of the threat of flash floods if the dams suddenly failed. In 2012, a whole village was swept away as a result of a landslide dam burst in the Seti River basin in Western Nepal (Schwanghart et al., 2016).

The geologic characteristics of an area are known to influence the drainage patterns, the nature of soils and land-use patterns. For instance, heavy rainfall is more likely to cause flooding in low-lying regions occupied with clay formations because clay formations have low infiltration capacities and therefore surface run-off is generated rapidly. The same heavy rainfall in zones occupied by sandy soil will not cause significant flooding since rapid

infiltration of rainfall reduces the likelihood of generation of a high volume of surface run-off. The topography of a region also determines land-use patterns and the patterns and intensity of erosion and landslides. It influences the gradient of rivers such that in areas with steep slopes, water flows rapidly into river channels. In such cases, the flood stage of a river is reached rapidly. In flat plains, the gentle slope reduces the velocity of flow leading to the formation of meanders and flood plains. Water in such areas is not transported rapidly and tends to pile up making the low-lying zones more liable to flooding (example Kano Plains). In Kenya, the most famous Nyando plains flash floods affect the lower part of Nyando that slopes towards the Nyakach Bay (Nyakundi et al., 2010). Other areas reported to experiences flash floods in Kenya include eastern, coastal and North Eastern parts of Kenya.

2.3.3 Vegetation Cover

Vegetation cover presented the ability of the soil to absorb the surface run-off from a rainfall event (Dominati, Patterson, & Mackay, 2010). Dense vegetation covers have more infiltration capacity and there is less water for the run-off. Sparse or no vegetation cover leads to little or no infiltration of surface run-off, causing more run-off waters to flow (Killeen et al., 2017). Depending on the soil characteristic and land terrain, surface run-off may cause a flash flood, in a rocky and clayish soil nature.

2.3.4 Soil type

Clay soil becomes saturated during heavy rainfall leading to an increase in water flow in the ground (Fetter, 2018). Porous soils allow for the penetration of water to the underground water table, however, clay and rocky soils allow surface runoff to pass, leading to increased runoff, finally causing an increase in water levels. Marigat Sub-County is characterized with a rocky and sloping terrain towards Lake Baringo. Rainfall experienced in the high altitude areas of the Tugen Hills has its surface runoff flowing to low land Marigat Sub-County. The soils in Marigat are highly eroded and thus reduce the infiltration and absorption rates of surface runoff (Deichsel, 2019). As a result, surface runoff from the high altitude areas, flowing to Lake Baringo, will lead to the flash flood occurrences in the area (De Cort et al., 2018).

2.3.5 Weather changes

Weather changes lead to differences in temperatures in different parts of the world. Kenya is one of the country's that have been heavily affected by climate change (Dai, 2011). The arid

and semi-arid Kenya is suffering extensively, due to the sudden climate variations experienced. Marigat suffers greatly from the effects of climate change, which include; too high temperatures, dry vegetation leading to sparse vegetation cover. This scenario aggravates the flash flood occurrences in Marigat.

2.3.6 Climate

Climate variability, precipitation is the main cause of disasters in the water resources sector. Abundant precipitation can lead to disasters such as flooding, water pollution, soil erosion, dam breaks, and water-related disease outbreaks and famine. On the other hand, scarcity of precipitation in areas, which ordinarily receive it, can lead to drought, water scarcity, loss of vegetation, loss of livestock and wildlife, famine and general suffering of people living in the affected areas (Chang & Franczyk, 2008). It is important that the characteristics and predictive potential of rainfall are factored in all the water resources management practices and policies in order to mitigate the adverse effects of disasters in the water resources sector.

2.3.7 Anthropogenic activities; Poor Land-Use and Degradation of Catchment Areas

Poor land use activities characterized by deforestation and clearance of bushes and other vegetation is the major cause of catchment degradation. Cultivation on steep slopes without applying soil conservation measures promotes soil erosion and rapid generation of surface runoff (Lake Basin River Catchment Conservation and Rehabilitation, 1987). Vegetation cover is important for it reduces the flow of surface run-off, making increased infiltration into the soil and replenish soil moisture (Opondo, 2013). The recharge of ground-water aquifers also takes place through infiltration and deep percolation of rainwater. Other causes of the degradation of catchment areas include poor construction of roads and footpaths, which are sources of sedimentation of waterways resulting in more runoff. Poor urban planning mechanisms promote the development of slums and many residential housing facilities, which discharge more runoff through sewage and domestic wastewater into river channels, thus degrading important water catchment sources.

2.4 Effects of Flash Floods

Flash floods have been rampant in Kenya over the last few years; previously Nyando plains had gained popularity due to annual flood occurrences that led to the loss of property, loss of lives (both animals and human being (Nyakundi, Mwanzo, & Yitambe, 2010). Flash floods have so many negative impacts that tend to affect the economy of a country, and in this case,

the Kenyan economy. The heavy rains experienced in most parts of the country, especially in Nairobi have led to the loss of human life, damage of property, destruction of crops and loss of livestock (Needham, Keim, & Sathiaraj, 2015). The Kenyan economy is greatly dependent on each of the areas that get affected. Communication links and infrastructure such as power plants, roads and bridges are damaged and disrupted and at the same time, some economic activities may come to a standstill as people are being forced to leave their homes and normal life is disrupted. Buildings, collapse due to the heavy pressure brought about by the flooding water and business come to a standstill (Kogo, Kumar, & Koech, 2019).

Most drainage systems within the city are not well maintained thus during such seasons, a lot of sewage spills are experienced. This is a very serious health hazard caused by stagnant water and wet materials in the home. Bacteria mould and viruses, cause disease, trigger allergic reactions, and continue to damage materials long after flash floods (Wolkoff, 2018). Similarly, disruption to the industry can lead to loss of livelihoods. These are the personnel who make the industries continue functioning and bringing about growth to the economy of Kenya. Heavy rainfall and flash floods affect the proper functioning of machinery in these industries and people may end up being electrocuted, thus some losing lives (Silver, 2016).

Damage to infrastructure also causes long-term impacts, such as disruptions to supplies of clean water, wastewater treatment, electricity, transport, communication, education and health care. Loss of livelihoods, reduction in purchasing power and loss of land value in the floodplains can leave communities economically vulnerable (Wilbanks et al., 2012). Flash floods traumatize victims and their families for long periods of time. The loss of loved ones has deep impacts, especially on children who end up being left orphans with no parents to look after them. Displacement from one's home, loss of property and disruption to business and social affairs can cause continuing stress. For some people, psychological impacts can be long-lasting.

Movement of water at the fastest speed due to lack of cover crops and overstocking has led to large quantities of soil eroded. According to researcher the amount of soil lost is 205-79 metric tons per hectare/year, meaning if strategies are not put in place the whole land can be lost through flash floods problems (Deichsel, 2019) .

Flash floods in key agricultural production areas lead to widespread damage to crops and fencing and loss of livestock. Crop losses through rain damage, waterlogged soils, and delays in harvesting are further intensified by transport problems due to flooded roads and damaged infrastructure (Sivakumar, 2014). The flow-on effects of reduced agricultural production often impact well outside the production area as food prices increase due to shortages in supply.

Damage to public infrastructure affects a far greater proportion of the population than those whose homes or businesses are directly inundated by the flood. In particular, flash flood damage to roads, rail networks and key transport hubs, such as shipping ports, can have significant impacts on regional and national economies (Gaume, & Borga, 2008). The tourism sector is also greatly affected by flash floods (Ziegler et al., 2016). While the impact on tourism infrastructure and the time needed to return to full operating capacity may be minimal, images of flood-affected areas often lead to cancellations in bookings and a significant reduction in tourist numbers.

2.5 Mitigation strategies on flash floods

There are various strategies that were employed to mitigate flash floods.

2.5.1 Traditional knowledge

Traditional knowledge refers to knowledge, skills, and practices that were developed, sustained, and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity (Nyakundi, Mogere, Mwanzo, & Yitambe, 2010). “Local knowledge”, on the other hand, refers to knowledge that people in each community have developed over time and continue to develop. It is based on experience, often tested over centuries, adapted to the local culture and environment and embedded in community practices, institutions, relationships, and rituals (MacnightNgwese, Saito, Sato, AgyemanBoafo, & Jasaw, 2018). Traditional and local knowledge is a way to understand “culture” and in so doing, understand the world. Transmitting a body of knowledge believes and practices of the use of locally available resources to improve human health and wellbeing is an important function of culture in traditional societies. Research in recent decades has shown that traditional knowledge contributes substantially to topics like community resilience, sustainable use of resources, and biodiversity conservation (Nyakundi, Mogere, Mwanzo, & Yitambe, 2010). The relevance of traditional and local knowledge in sustaining

natural resources and improving disaster preparedness has been identified in different socio-ecological regions of the world.

MacnightNgwese, Saito, Sato, AgyemanBoafo, and Jasaw (2018), in their study in Northern Ghana, found that the local communities were utilizing the hippopotamus behaviour to determine an impending flash flood. The locals believed that whe hippopotamus ventures inland, there is a flash flood coming, most of the time these animals spent most of their time in water except when there is heavy rainfall that could cause flash floods. In western Kenya, the local communities were found to have a number of traditional weather forecasting knowledge, for example when the bones of the old people began itching, frogs croaking, heavy lightning and thunder at the river, heavy and persistent rains together with rising water levels in the river is a sign of upcoming heavy rainfall (Nyakundi, Mogere, Mwanzo, & Yitambe, 2010).

2.5.2 Forecasts

Climate change events are currently addressed based on meteorological weather forecasts; various departments in questions are dependent on the department's projections for their early preparation on how to avoid disasters. 'Early Warning Early Action' has been a common phrase used by the humanitarian aid organisations in their bid to address an incoming disaster. The scientific community addresses the effective way of approaching a disaster is through early warning. this allows room for the affected communities to prepare and or to avoid the disaster altogether, for example, an early warning of an upcoming heavy rainfall in a flood-prone area, will allow the residents to evacuate the area early enough before the onset of the rains. On the other hand, people living in flood plains should also vacate the area early enough before the onset of the rains. Floods experienced in MarigatSub County have been due to lack of early warning system is used by the communities. Adoption of the early warning system should allow the communities living in Salabani, Ngambo and Ilng'arua to vacate the Lake Baringo region early enough before the onset of the rains.

2.5.3 Cash transfers program

Studies indicated that the victims of climate change disasters were often people of poor communities, especially marginalised communities in Kenya. Therefore implementing a cash program helped in reducing the effect of a flash flood event through enabling residents avoidance risk prone environment. This is explained as follows if a poor family is financially

empowered they will be in a capacity to evade a flash flood event, move to safer areas before the rains. comparing the cash transfer program to the Nyando plains residents, if the residents had received cash transfer prior to the rains most of them could have saved their commodities and families from the effects of flash floods. Lack of financial ability, allowed them to be caught up by floods, and the majority were moving away after the flash floods which had swept their residential areas, this scenario is replicated in most parts of Kenya, where flash flood occurs then the aid comes in later after the effects have been felt. Kenya Government recognises the benefits of social protection through cash transfers, it is described as Policies and actions (Suroso, Sagala, Alberdi, & Wulandari, 2018), including legislative measures, that enhance the capacity of and opportunities for the poor and vulnerable to improve and sustain their lives, livelihoods and welfare, enable income-earners and their dependents to maintain a reasonable level of income through decent work, and ensure access to affordable healthcare, social security, and social assistance.

2.5.4 Humanitarian aid

Humanitarian aids known for addressing emergency situations in Kenya include Kenya Red Cross Society, St John Ambulance Kenya and the Kenya Police (Owuor, 2015) Among these are other Non-Governmental Organisation such as AMREF, CARE international, and Concern world, that have also been on the lead in addressing the emergencies that occur due to floods in the Arid and semi-arid lands. However, these responses are short lived since they always come in after the flood event has occurred.

2.5.5 Building of bridges

Innovations are essential in management of flash floods in Kenya. Areas that are prone to this natural disaster were flat such that construction of bridges required skills to raise the facility to accommodate the large unpredicted quantities of water. Engineers have been advising and managing constructions of raised bridges to enable passage by vehicle, people and animal during rainy season to the other side (Akivaga, 2010) .

2.6 Theoretical framework

This study adopted the percolation theory in determining the management practices in flash flood occurrence. A rainfall threshold approach was developed and used within the U.S. National Weather Service (NWS) flash flood watch/warning programme (Toth, 2016). Flash flood warnings and watches were issued by local NWS Weather Forecast Offices (WFOs), based on the comparison of flash flood guidance (FFG) values with rainfall amounts. FFG

refers generally to the volume of rain of a given duration necessary to cause minor flooding on small streams. Guidance values were determined by regional River Forecast Centres (RFCs) and provided to local WFOs for flood forecasting and the issuance of flash flood watches and warnings. The basis of FFG was the computation of threshold runoff values, or the amount of effective rainfall of a given duration that is necessary to cause minor flooding (Corral et al., 2019). Effective rainfall was the residual rainfall after losses due to infiltration, detention, and evaporation was been subtracted from the actual rainfall: it is the portion of rainfall that becomes surface runoff at the catchment scale.

The determination of FFG value in an operational context requires the development of (i) estimated threshold runoff volume for various rainfall durations, and (ii) the relationship between rainfall and runoff as a function of the soil moisture conditions to be estimated for instance via a soil moisture accounting model (Camporese, Paniconi, Putti, & Orlandini, 2010). The percolation theory helped in my study to quantify the amount of water discharge to rivers and land surfaces due to poor infiltration rate from the type of soil in the environment. It also explained the lack of vegetation that slows the speed of water enabling absorption to the soil and has better use by plants. Thus the large volume of water that created.

2.7 Conceptual Framework

The conceptual framework was derived from percolation theory in the literature review. The independent variables of this study include weather changes, vegetation cover, relief/topography, and soil type and rain intensity/duration. The dependent variables of the study include management of flash flood; traditional knowledge, cash program, humanitarian aid and building of bridges. Intervening variables include existing policies, education level, gender and age. The household heads, key informants, government officials (chief/assistant chief, Sub County disaster Management officer) facilitated in providing information. Figure 4.1 below illustrates the conceptual framework.

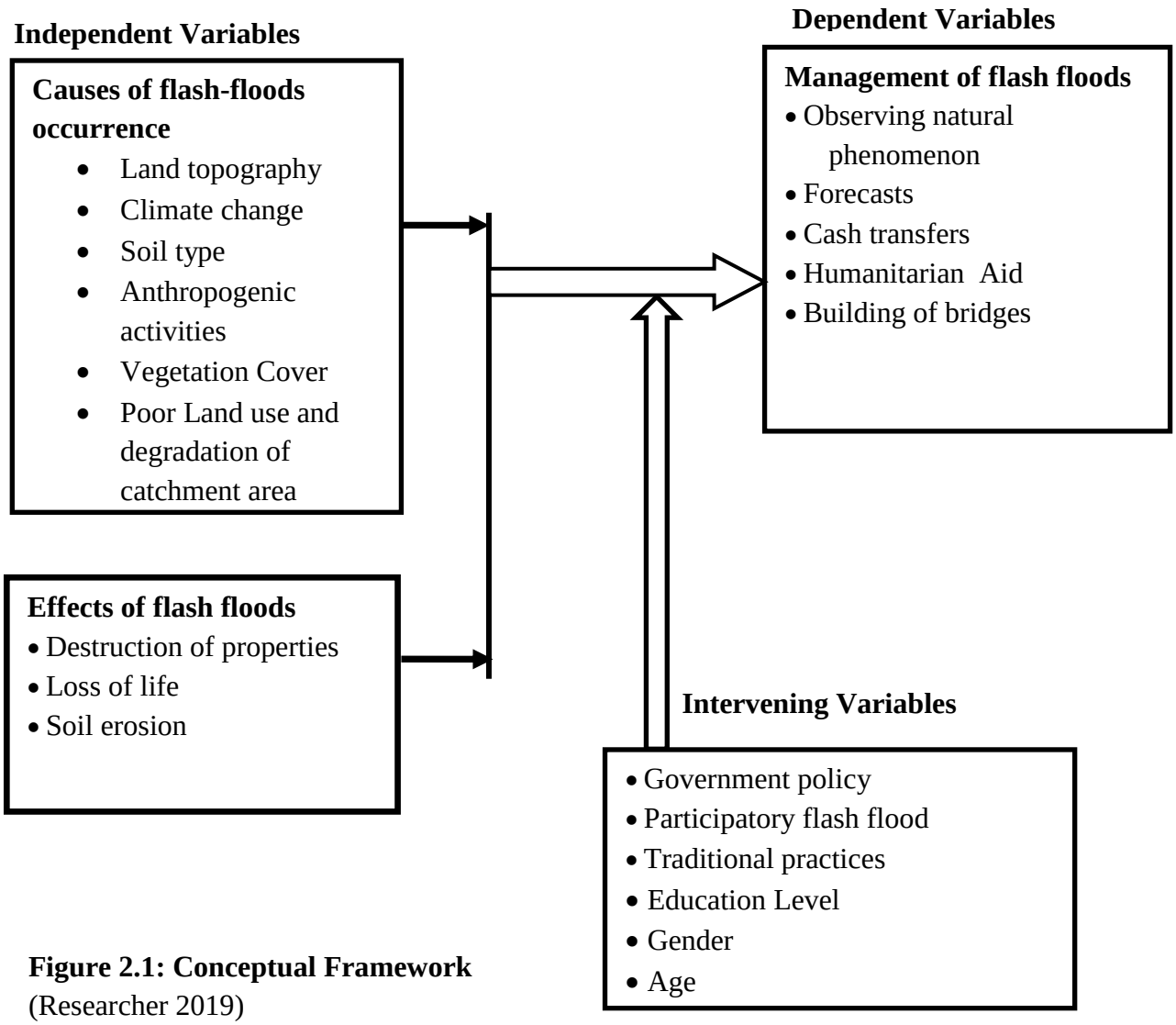

Figure 2.1: Conceptual Framework
(Researcher 2019)

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter presents the research design, location of the study, population, sampling procedure and sampling size, instrumentation, pilot study, data collection and procedure, data analysis, and ethical considerations.

3.2 Research Design

A descriptive research design was used in this study to determine the causes, effects floods and appropriate management practices of flash floods. This will provide both qualitative and quantitative methods (Desai & Hoyer, 2000). This design was appropriate since it provided quantitative and qualitative data, also gave characteristics of the population which was studied.

3.3 Location of the Study

Marigat Sub-County is in Baringo County. It is located in latitude 0° 28’ 21N and longitude 35° 59’ 16E. Baringo is one of the 47 counties in Kenya, situated in the Rift Valley region. It borders Turkana and Samburu counties to the North, Laikipia to the East and Nakuru to the South, Uasin Gishu to the Southwest, and Elgeyo-Marakwet and West Pokot to the West (Ezenwa, Ibe, & Ochor, 2018). Appendix IV: shows a map of the location of the Study. The area has an altitude of 1060metres above the sea level and a mean temperature of about 32.8°C ± 1.6°C with an annual average rainfall of 512 mm occurring in two seasons: March to August and November to December. Soil found in this area is mainly clay that does not allow water to infiltrate leading to more surfaces runoff on land when there is more rainfall. The soil is easily eroded due to lack of cover crop and overstocking of livestock.

3.4 Population of the study

The total population of Marigat Sub-County was 20,893 households (Kihu *et al.*, 2015). The study targeted three locations : Ng’ambo, Salabani and Ilngarua locations affected by flash floods with a population of 3,168 households (Kihu *et al.*, 2015). The locations have three chiefs and a disaster management officer who were the key informants. Focus group

discussion was held, facilitated by a trained local research assistant comprising of 6-12 people in every location.

Table 3.1: Population of Marigat Sub-County in 2019.

NO.	LOCATIONS	MALE	FEMALE	HOUSEHOLD
1	Kimalel	2,844	2,817	1,390
2	Marigat	8,595	8,661	4,369
3	Salabani	3,119	3,217	1,279
4	N'gambo	3,579	3,496	1,261
5	Ilchamus	2,143	2,303	889
6	Sandai	1,676	1,750	606
7	Kipkuikui	727	900	286
8	Loboi	1,444	1,405	592
9	Kimondis	915	887	441
10	Ilng'arua	1,703	1,702	628
11	Ewoleleisoi	929	886	428
12	Mukutani	3758,	3,761	537
13	Kiserian	2,333	2,361	866
14	Mochongoi	17,348	16,842	7,067
15	Kimoriot	5,902	5,366	2,606
16	Arabal	2,578	2,526	911
17	Chebinyinyi	2,040	1,985	737
	TOTAL	59,490	60,773	24,893
	TOTAL POPULATION		**120,263**	

Source: (KNBS, 2009)

3.5 Sampling procedure and sample size

3.5.1 Sampling procedure

Purposive and proportionate sampling methods were used to obtain the sample .Three locations were purposively selected based on agro-ecological zone. Ilngarua, Ng'ambo, and Salabani locations were selected out 17 locations because they are lowland zone in the Marigat Sub County. Lowlands are frequently affected by flash floods. Households were stratified proportionate to the house holds populations. Those who were interviewed were selected using systematic random sampling method. Purposive sampling method was used to obtain sample for Key informants, focus group discussions and County disaster management

officer. The sample size for each was calculated and a ratio was used to acquire the accurate sample size for each targeted population.

3.5.2 Sample size

According to Bartlett et al., (2001) the following formula for sample size calculations applies:

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

This formula enables the comparison of a variable in scientific study. Where n was the sample size, N was the households, e to be 0.5 N =3168. The representative sample size of my study was: n = 3168/1+3168(0.05)^2 = 355.

The sample size derived from the above formula was proportionately distributed to the three locations using the proportion allocation to size formula by Salkind (2010)(Salkind, 2010) the following formula was used to get the households proportion required for each of the three locations.

$n_h = n\frac{Nh}{N}$ (Salkind, 2010).

Where n_h, was the sample size per location (Salabani, Ilngarua and Ng'ambo) n, was the total sample size of the study N_h was the total population per location, N was the total population.

Using the proportionate sample size formula;

$$n_{Salabani} = 355 \times \frac{1279}{3168} = 144$$

$$n_{Ngambo} = 355 \times \frac{1261}{3168} = 141$$

$$n_{Ilngarua} = 355 \times \frac{628}{3168} = 70$$

According to the above formula, the sample size of the specific locations was 145, 143 and 71, for Salabani, Ngambo and Ilngarua respectively.

Table 3.2: Ratios as per household population in the locations

Location	No. of household	Sample size
Ilng'arua	628	70
Ng'ambo	1,261	141
Salabani	1,279	144
TOTAL	**3,168**	**355**

An interview was conducted on the key informants who were the three chiefs from the respective locations and one county disaster management officer working in Marigat Sub-County. Therefore the total sample size for the study was 359.

3.6 Instrumentation

Questionnaires

This was prepared to answer the objectives of the study. This tool was convenient for carrying out a survey for the large population because the result renders itself for analysis (Ochieng & Koske, 2013). These questionnaires were administered by the researcher and the research assistant to the household heads who responded to the accordingly, to increases the response rate and clarify the questions when needed to.

Interviews

The key informants were interviewed who had history of the area and knowledgeable about the flash floods causes, effects and management by the community in Marigat Sub County. This was guided by an interview guide in section 3.

Non- participant observation

This was done by the researcher through observations of phenomena of interests under this research study such as the terrain of the area, effects of flash floods and management practises by the community. This was guided by an obsevertion check list in Apendix 4 where it was marked appropriately.

Focus group discussion

This was done in every location through the chiefs. Members were purposively selected by the chiefs in respective locations involving 6-12 members. The discussion followed a group discussion guide in the appendix. This discussion helped to give an overview of the problem under study. (Appendix I section 3: Focus group discussion guide).

Photography

Photographs were taken during the study as evidences of observed features and activities of the study. This was meant to support collected data from the respondents for example focus group discussions, interviews, a distance where flood reaches, affected properties that includes schools, chiefs' offices, dispensaries, houses among others.

3.6.1 Pilot study

The pilot study was done in Ng'ambo location and involved 20-30 household heads purposively identified. This location was among the studied area and the respondent selected during the pilot study were not used during the actual study. A randomly stratified method was used where it was assumed that houses are arranged in a linear manner and the household head of house number two from a fixed position in the piloting area was selected as the first respondent and every after four houses a household head was selected as a respondent.This ensured their was no repeatation of using the same respondent. The reason for choosing this area is because they are affected by the same natural disaster and have some similarities with the other study population.

3.6.2 Validity of the Instruments

Validity is the extent to which an idea under study is measured accurately by a given instrument (Kumar, 2019). The validity of the study was achieved through the construction of relevant instruments to the objectives of the study under the guidance supervisors who would advise accordingly.

3.6.3 Reliability of the Instruments

Reliability is the precision at which an instrument produces similar results over several trials when putting to test repeatedly (Quimby, Vig, Rashid, & Firestone, 2004). The data collected during piloting was used to test for reliability using Cronbach's alpha and confirmed the outcome for the causes of flash floods was 0.70, effects of flash floods was 0.73 and mitigations measures of flash floods was 0.71 proving a good instrument because any value less than 0.7 is not acceptable (Radhakrishna, 2007).

3.7 Data Collection Procedures

The researcher followed the stages required in the collection and presentation of the data. Focus group discussions was held before the use of other study instruments so that the researcher understands the environment since the key informant comprising of 6-12 respondents had the vital information of the study area. A stratified method was used to administer questionnaires to the household heads who gave information on the study in the three locations (Salabani, Ng'ambo, & Ilngarua). It was assumed that households were in a linear format such that the first household head was interviewed and after every three houses

the fourth one is a respondent of the study until the last one is interviewed in the location. The next two locations followed consecutively. As per the 355 respondent expected, Nine days was used to collect the data such that three days was used to interview and collect relevant data per location . Photography was used to provide evidence for the study.

Before data collection exercise began Kabarak University provided an introductory letter to National Commission Science Technology and Innovation (NACOSTI) to facilitate the application of research permit. NACOSTI upon issuing of the research permit to introduce to allow the collection of the data, the researcher submitted it to Marigat Sub-County disaster management officer and the key informants. The researchers meet the key informants and agreed on the programme, date and time. The researcher and research assistant delivered the questionnaires to the respondents who filled it and were available to clarify the questions.

3.8 Data Analysis

Data collected was coded, cleaned organised, transformed and modelled using SPSS Version 23 software. Descriptive statistics included frequencies distribution and . Chi-square was adopted for inferential statistics to test the hypothesis.

Table 3.3: Data analysis table

Objectives	Independent Variables	Dependent Variables	Method of analysis
To determine the causes of flash floods in Marigat, Sub-County.	• Land topography • Climate change • Soil type • Vegetation cover • Poor land use & degradation of the catchment area	Improved awareness of flash floods	**Descriptive statistics** • Frequency distribution **Inferential statistics** • Chi-square test
To establish the extent of perceived effects of flash floods in Marigat Sub-County.	• Destruction of properties • Loss of life	Reduced effects of flash floods	**Descriptive statistics** • Frequency distribution **Inferential statistics** • Chi-square test
To determine mitigation strategies of management of flash floods in Marigat Sub-County.	• Observing natural phenomenon • Forecasts • Cash transfers • Humanitarian Aid	Improved control of flash floods	**Descriptive statistics** • Frequency distribution **Inferential statistics** • Chi-square test

3.9 Ethical considerations

The relevant authorities gave permission to facilitate this research to be carried out. These were Kabarak University issuing an introductory letter to National Commision of Science and Techonolgy (NACOSTI), and later NACOSTI issuing a permit to enable the researcher to carry out data collection.The researcher went with research permit to Baringo County where he was it was forwarded to The chiefs of the respective location for the study. The researcher ensured confidentiality for all the data collected in the field and privacy of the information provided by he respondents during the study. The use of the data was only for academic purpose and respondents will be assured and encouraged to give right information useful for the study.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSIONS

4.1 Introduction

This chapter presents data analysis, presentation and discussions on the effects and management of flash floods in Marigat Sub County. The results are within the framework of the study objectives and hypothesis outlined.

4.2 General and Demographic Information

This sub-section presents descriptive analysis, findings and discussions of results of the research study carried out in three locations namely, Illing'arua, Ng'ambo and Salabani, Marigat sub county. The study unit was household heads (HHH). Presentation of results are in form of frequencies, percentages, bar graphs and tables.

The response rate of the respondents was determined before the analysis. Out of the 359 questionnaires, 310 were returned. However, all the 310 returned questionnaires were not completely filled but it were considered for analysis. Table 4.1 illustrates the distribution of returned and unreturned questionnaires. According to the results in table 4.1, the return rate of the questionnaires was at 87%, which was deem fit for the study (Axhausen, Schmid, & Weis, 2015)

Table 4.1 Response Rate of the respondents

Rate Response Rate	Frequency	Percent
Returned	310	87
Unreturned	48	13
Total	359	100

This were the response analysed in the study and it represents the whole population, what this sample provides was acceptable.

4.2.1 Demographic data

This section presents the demographic characteristics of the study respondents. The respondents were 355 household heads, 3 chiefs of the three locations and disaster management officers. Gender, age, education level and number of years lived in the study

area of respondents were analyzed to determine their relationships with the flash flood occurance, effect and management in the study area

.4.2.1.1 Gender and Age of the household head

The study sought to identify the gender and age of the respondents to determine any relationship with the effect and management of flash floods in the study area. The results are summarized in table 4.2.

Table 4.2: Gender and Age of the househouse head.

GENDER	**AGE IN YEARS**															
	18-25		26-33		34-41		42-49		50-57		58-65		over 65		**TOTAL**	
	freq	%	Freq	%	Freq	%	Freq	%	freq	%	freq	%	freq	%	freq	%
Female	11	3.7	12	4.04	26	8.75	17	5.72	1	0.34	6	2.02	3	1.01	76	25.59
Male	26	8.76	39	13.13	68	22.9	44	14.81	11	3.7	28	9.43	5	1.68	221	74.41
Total	37	12.46	51	17.17	94	31.65	61	20.54	12	4.04	34	11.45	8	2.69	297	100

In table 4.2 the gender results indicated that, 74.41% of the household heads were males and 25.59% of the household were females. The male household heads were the majority in the study area. This means that, male household heads (HHH) would be aware of the effects and management of flash floods in the study area. Gender is relevant since males are likely to be resilient and females are mostly affected by flash floods. Women are vulnerable to environmental disasters since they are at home during the occurences (Oakley & Momsen, 2005).

In the same table 4.2 The age of the household heads was determined. The results indicate that, the majority of the respondents 61% were young between age 18- 41, 21% of them were in middle age 42-49 years and 18% were above 50 years of age. This therefore means that, the target population consisted of young household heads. Age of the household heads is important in that, the older people have better information regarding the occurrence, effects and management of flash floods because they may have learnt and have experience about the flash floods than the younger generation. Minh, (2019) found the same results confirming the researchs findings. People who have lived in a particular environment for a long time are knowledgeable of the flash floods through indigenous knowledge and experience of the natural hazards occurring in the study area (Morss, Demuth, Bostrom, Lazo, & Lazrus, 2015).

The study therefore used all the sex and age of the household heads present at the time of study and the results wholy an experienced was to provide better management skills and strategies for flash floods phenomena.

4.2.1.2 Educational Level of the household head.

The study sought to identify the education level of the households. The results are summarized in table 4.3.

Table 4.3: Education level of the households

	EDUCATION LEVEL											
GENDER	Illiterate		Certificate		Undergraduate		Masters		PhD		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			Freq.	%
Female	39	12.79	16	5.25	14	4.59	7	2.3	1	0.33	77	25.26
Male	73	23.93	103	33.77	46	15.08	6	1.97	0	0	22.8	74.74
Total	112	36.72	119	39.02	60	19.67	13	4.26	1	0.33	305	100

Table 4.3 above shows the education level of the household heads found in the study area. 39% had primary and secondary level of education, 25% had degree level and 36 were illiterate. These results showed that majority of the respondents had certificate education at 39%, 36% were illiterate but with informal education. The results mean that, majority of the household heads had reasonable firm of formal schooling, hence would be knowledgeable about effects and management of flash floods in the study area.

Despite reports that literacy levels in Kenya stands at 78%, the illiteracy level in the study area is comparable to national records of illiterate people in Kenya, who are found to be at 39% (Abubakar & Fischer, 2012). Education is key in flash flood areas because educated people are informed of the likely disaster that arises when rainfall is experienced. This finding is in line with other researchers who found similar results in other areas (Bui *et al*., 2019). It can also be concluded that, despite household heads being illiterate, most of them could rely on indigenous knowledge on flood prediction and environmental factors.

Education being understanding of environmental concern of flash floods, the analysis have shown that all the people are aware of this issue due to knowledge concept from formal and informal eduction which contribute positively to this study.

4.2.1.3 Years Lived in the Area

The study further, sought to identify the duration which the households have lived in the flash flood prone area. The findings are presented in table 4.4.

Table 4.4: Years lived in flood prone areas

Time lived	Frequency	Percentage	X^2	P>Chi-SQ
3-5 years	28	9		
One year	3	0.96	665.2701	<.0001
Over 5 years	274	88.1		
Two years	6	1.93		
Total	310	100		

In table 4.4, the majority of the respondents 88% household heads have lived in Salabani, Ng'ambo and Ilngarua locations for more than five years, 12% have lived less than five years. Living for more than five years in the area is assumed that the respondent has had enough knowledge on the frequent occurance of flash floods and may have developed resilience on management of flash floods and also allowed the researcher to collect factual information from the respondents, based on their flood experiences. The study further observed that, number of years lived had a chi square of 665.2701 with a p-value = 0.001 which is less than 0.05 significant level. This means that there is significant association between numbers of years lived and flash floods on the respondents. The people who have lived informed of various aspects of flash floods. According to Mavhura, Manyena, Collins, & Manatsa, (2013) traditional knowledge on environmental factors including rainfall, climate change, soil types, soil erosion and flash floods are understood well by the residents who have lived longer in a flash flood area probably five years and above.

4.3 Causes of Flash Floods

The second part of chapter four presents the analysis of the three specific objectives and three hypotheses. The study accept or reject the three hypotheses stated in the study area through the analyses.

The first specific objective of the study was to determine the causes of flash floods in Marigat Sub-County. In attempt to achieve this objective, the respondents were asked to give their opinion on the causes of flash floods. The study findings are indicated in table 4.5 below.

Table 4.5: Causes of flash floods

Causes of flash floods	SD	D	UN	A	SA	χ^2	P> χ^2
Clearing of vegetation	6.2	12.2	4	24.6	53.2	159.1	<.0001
Climate change	2	7	29.0	11.4	50.6	297.9	<.0001
Topography		1	15.0	35.8	48.2	144.5	<.0001
Unsustainable farming practices	0.2	4.1	10.2	30.5	55	220.3	<.0001
Overstocking	3.2	2.3	5.5	20.2	68.8	260.7	<.0001
Siltation		3.9	7.3	50.6	38.2	255.2	<.0001

In table 4.5 above, the findings indicate that, 53% of the respondents agreed that flash floods in Marigat Sub-County is caused by vegetation clearance with chi-square 159.1 and p <.0001, 25%, followed by 18% disagreeing. From the findings of the study, vegetation clearing is a major cause of flash floods in the study area. Vegetation cover is important in checking the speed of water and holding it back so that the effect of the flash flood water is minimized and the loss of life, property, soil erosion and biodiversity is controlled. There is therefore need to mitigate flash flood flooding by planting more trees and cover crops in the study area. This finding is supported by (Dominati et al., 2010) who found that loss of vegetation cover increase the chances of flash floods through run-off. Regarding climate change as a cause of flash flooding, 51% strongly agreed at Chi-square 297.9 and p value which is less than 0.005 showing that, climate change has some influence to small extent on flash flood occurance. 11% agreed, 29% were not aware, 7% disagreed and 2% strongly disagreed. Climate has been attributed as one of the major causes of flash floods in the world, as found in other studies (Chang & Franczyk, 2008).

On topography, 48% of the respondents strongly agreed. The study also found that there was significant association between the perception of respondents and the topography of the land since the chi square = 144.5 with a p- value= .0001 which was less than 0.05 significant level. This show that majority of the respondents indicated that topography significantly contribute to the flash flood. Further, 36% agreed, 15% did not know while 1% disagreed. Marigat Sub-County the study area is adjacent to high steep Tugen hills which sloped towards the study

area making flash flood run off to move with speed hence causing impact. This finding is similar to results obtained by Sene, (2016). Unsustainable farming practise causing flash floods was strongly agreed by 55% of the respondents, while 31% agreed, 10% were not aware and 4% disagreed. The finding indicate that, unsustainable farming practice significantly caused the flash flood to occur in the study area. The adoption of farming practices such as slashing and burning has left the land bare without a vegetation which improves soil texture and infiltration of water into the ground, this leads to increased surface run-offs which is linked to flash floods (Opondo, 2013). The traditional methods of keeping large numbers of livestock has caused de-vegetation of the land, this was strongly agreed, by 69% of the respondents. The study also found that there was association between the perception of the respondents and the overstocking of the livestock since the Chi-square = 260.7 with a p value = 0.05 significant level. The second highest responses were those who agreed, at 20% while the lowest responses those who were not aware, 5%. It can be concluded that all the variables measured in the testing of the objective one were siginicant in causing flash floods and vegetation clearance was the most variable casing flash floods in the study area.

Overstocking has led to vegetation degradation through animals feeding on grass, leaves and shrubs leaving the ground bare and erodible by agents of erosion (Gaume & Borga, 2008b).Siltation as a cause of flash floods in the area was supported by a majority of 59% of the respondents who agreed. The study also found that there was association between the perception of the respondents on siltation and flash flood occurrence since the chi-square = 255.2 with a p value <.0001 which was less than 0.05 significant level, while 38% percent strongly agreed with the statement and the least were 4% who disagreed. Siltation has led to reduced depths of the rivers which makes it to burst their banks because they cannot contain the huge volume of water leading to flash floods (Opondo, 2013).

It is important to note that various factor contribute to adverse effects of flash floods, that when one factor has contributed positively to the effects the othe one increases resulting to more damaged environment for example overstocking leads to increase effects of flooding but also results to soil erosion realised more in the study area. Therefore one effect leads to another adverse effect for all the fertile soil is swept aware making the area poor agricultural production zone.

4.3.1 Occurrence of Flash Floods

The study sought to identify if flash floods occurred in the study are during rainy season. The results are presented in figure 4.1 below.

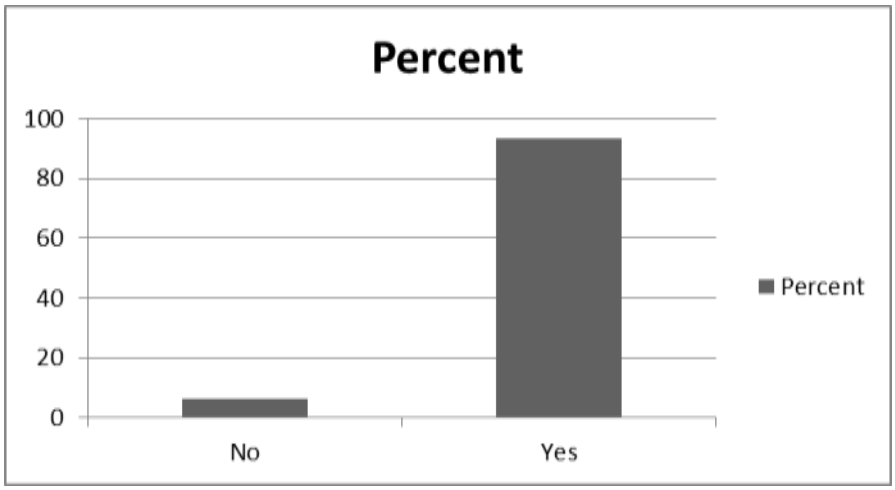

Figure 4.1 Respondent Opinion on occurence of flash floods

Figure 4.1 illustrates that, 94% agreed that flash floods occurred during the rainy seasons in the study area. However 6% disagreed on the statement that flash occurred in the area during rainy seasons. This illustrates that occurrences of flash floods affected almost all the people in the study area leading to an environmental concern that requires attention by the local community, county government, National government and Non-governmental organisations (Ochuka, Ikporukpo, Mijinyawa, & Ogendi, 2019).

Further, the researcher sought more information on the causes of flash floods in the study area through focus group discussion consisting of eight participants. Focus group discussions conducted at the chiefs' office was held on 14th September, 2019 in the presence of the chief and village elders. It was reported that, they could wake up in the morning and get water in their door yet there was no rain in the study area. This is evident in plate 2 in appendix VII. During the study, flash flood water was seen in the morning of 14th July 2019 in Ng'ambo location. The elders further reported that this phenomenon frequently occur when there is rainfall in the highland areas towards Tugen hills. Therefore the focus group discussion held provided knowledge that enabled the researcher be equipped during the study since they were able to provide long term matters concerning flash floods.. According to Silver (2016) focus group discussions facilitate informations experiences understood and have the best practises to address the matter.This enabled the researcher have an overview of what the ocal knew about flash floods in the study area.

4.3.2 Types of Flash Floods

The study sought to identify the types of flash floods in the area. The respondents were therefore, asked to mention the types of flash floods they experienced. The findings are presented in table 4.6 below.

Table 4.6: Types of flash floods experienced

Types of flash floods	Frequently in Percentage	Moderately	Not at all	Monthly	X^2	P>CHISQ
Home flash flooding	73.87	25.81	0.32		259.4	<.0001
Riverbank flash flooding	60.14	39.86			12	<0.0001
Lake flash flooding	53.15	22.03	1.05	23.78	157.4	<.0001
Pond flash flooding	16.02	30.1	2.43	51.46	108.4	<.0001

Table 4.6 indicated that home flash flooding was the most common at 74%. Home flash flooding occurs when runoff water flows directly into someone's house and cause flash flooding. The study further observed that, the home flash flooding had a chi square of 259.4 with a p-value = 0.001 which is less than 0.05 significant level. This means that there is significant home flash flooding in the study area. River bank flash flooding was the second most common type of flash floods at 60%, followed by lake flash flooding at 53% and lastly, pond flash flooding at 16%. The study also found that both the river flash flooding and the lake flash flooding had a p- value= 0.0001 which was significantly less that 0.05 significant level. This means that there is suficient evidence that perception of the residence on occurrence of the flash flood is significant.

It was further observed that, the study area topography was flat which necessitate flow of water into the neighbourhoods causing flash floods occurrences. According to (Liu *et al.*, 2018) water moving from highlands to low land was experienced and this gets people unaware of the calamity in the environment. The flash floods in the low land is attributed to the gradient difference between the low lands in which the study area falls and the highlands prone to heavy rainfall.

4.3.3 Flash Floods Frequency in the Area

The study further asked the respondents to indicate the frequency at which the flash floods occurred. The findings are presented in table 4.7.

Table 4.7: Frequency of flash floods occurrence in the study area

Time of occurrence	Frequency	Percentage
One after 3 months	24	7.69
Once a year	80	25.64
After some years	10	3.21
Frequently	14	4.49
Frequently when it rains	25	8.01
Once there is rainfall	3	0.96
When there is a lot of rain	156	50

Table 4.7 showed that there was flash flood occurrence in the study area every year according to the majority respondents 50%. This proved that the frequency of flash floods during rainy season was due to heavy rainfall with low percolation and infiltration rate arising from poor drainages and lack of vegetation cover in the area causing soil erosion. This is consistent with Opondo (2013) results, who indicated that heavy rainfall has been linked to flash floods in many areas of the country. 3% of the respondents indicated that flash floods occur once there is rainfall in the study area. Therefore poor drainage and low infiltration rate in the soil results to increase water run off in flat area leading to flash floods.

4.3.4 Origin of the Flash Floods

The researcher sought to identify the origin of the floods. The respondents' results are presented below in table 4.8.

Table 4.8: Origin of flash flooding

Source	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	X^2	P>CHISQ
Over flooded rivers	0.64	0.32		45.83	53.21	303.5	<.0001
Over flooded lakes	0.65	15.36	1.96	49.67	32.35	268.4	<.0001
Over flooded ponds	3.35	25.94	8.79	57.74	4.18	252.5	<.0001
Over flooded roadways	0.84	10.04	1.67	59.41	28.03	289.2	<.0001
Lack of vegetation on land	1.68	20.59	1.26	40.34	36.13	162	<.0001
Unknown	4.82	58.33	7.89	25	2.63	335.9	<.0001

Table 4.8, shows that the majority of the respondents at 53% strongly agreed that flash floods experienced were as a result of over flooded rivers when it breaks their banks. The study observed that there is association between the over flooded rivers as the origin of the flash flood and the perception of the residence on the origin since the chi square =303.5, with a p=0.0001 which was less than 0.05 significant level. The rivers running through the area were

Perkera, Endao and Molo which are both permanent and seasonal rivers. Over flooded ponds was agreed by 58% of the respondents for flash flooding. Further, 59% of the respondents also agreed that over flooded roadways was a source of flooding in Marigat. Those of the opinion that flash flood was due to lack of vegetation were 40% of the respondents. The study therefore found that there is association between the perception of the residence that flash flood origin was over flooded road ways since the chi square=268.4 with a p-value= 0.0001 which is less than 0.05 significant level. According to Opondo (2013), vegetation is important in preventing run offs, promotes percolation of water into the ground increasing infiltration rates hence avoiding flash floods. Further the study found that the over flooded road ways and lack of vegetation were also sources of the flash food in Baringo. According to community as per the respondents outcomes, flash floods are contributed by more than one item for example overflooded rivers, lakes, ponds, road ways and lack of vegetation have resulted to increased volumes on moving water in the land. This water leads to causes of flash floods as cumulatively experienced.

4.3.5 Neighbor Flash Flood Experience

The study sought to identify if the neighboring community experienced the flash floods as the respondents did. Respondents from the locations were therefore, asked to indicate if the flash floods affected their neighbours or not. The findings are showed in table 4.9 below.

Table 4.9: Neighbours who experience flash floods

Neighbor (location)	Frequency	Percent
Eldume	143	53.36
Illing'arua	63	23.51
Kiserian	21	7.84
Kiserian and Loboi	3	1.12
Loboi	16	5.97
Loboi and Eldume	2	0.75
Ng'ambo	31	11.57
Ng'ambo and Kiserian	1	0.37
Ng'ambo and Loboi	2	0.75
Salabani	48	17.91
Salabani and Eldume	1	0.37

According to the table 4.9, the majority at 53% pointed that Eldume as the most affected. Ilngarua was mentioned by 23% of the respodents, Salabani by 18% and Ngambo by 12%. The mentioned locations as the areas which mostly experience flash floods during rainy seasons was supported by information documented by Rael (2018). Therefore the three

locations under study were the most affected area and their neighbors also felt the problem and the respondents gave there opinions on how they see them.

4.3.7 Flash Floods Distribution per Year

The study sought to identify the flash floods distribution throughout the year in attempt to achieve objective one. The findings are shown in figure 4.2 below.

Figure 4.2: Annual flash flood distribution

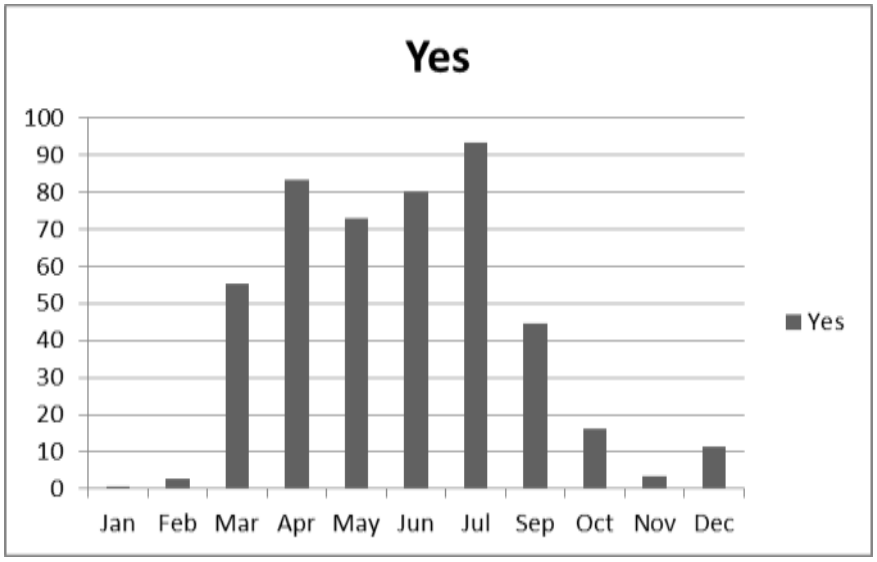

Figure 4.2 Flash floods occurrence

Figure 4.2 indicated that, the months of January and February did not experience flash floods. It was further indicated that between the months of March to September flash floods were experiences, with the highest occurrence being July at 93%. This is supported Kenya metrological department weather outlook press releases for 2019 (Oladele et al., 2018) which indicated high rainfall in the Months of March to July. It was also indicated that, there was a gradual decline in flash floods experienced from October to December registering between 15% to 3 % with the lowest being November.

Moreover the people in the study area were experiencing flash floods eight months of the twelve months of the year, meaning that they are living with this natural calamity almost throughout there live time.

4.3.8 Events Causing Flash Floods

The researcher sought to find out the types of events leading to flash floods. Therefore, classified the types of flash floods according to its severity. The responses were as shown in the table 4.10 below.

Table 4.10: Description of the type of flash flooding

	Considerable extent	Little extent	Moderate extent	Large extent	No extent	CHI SQ	P>CHISQ
Home flash flooding	13.55	1.59	6.77	78.09		384.5	<.0001
River bank flooding	23.97	5.48	10.27	60.27		107.6	<.0001
Lake bank flooding	5.61	14.02	33.64	45.79	0.93	98	<.0001
Pond flash flooding		26	44	30		2.66	0.26

The results from table 4.10 indicate that the residents had good knowledge on the type of flash flood in the areas and the extend of each type of flash flood. The study indicate that there is significant association between the knowledge of the type of flash flood and the extent of the flash flood in the area since all the p-values were less than 0.05 significant level. According to table 4.10 above on description of the types of flash floods, home flash flooding occurrence was rated the highest with 78 %, River bank flash flooding was at 60% and lake flash flooding was at 45 %. The type of flash floods experienced in the study area and its contribution to environmental problem was evident by availability of water on the ground surfaces in the area. Pond flash flooding was rated as the least in terms of the severity while a combination of the other three types of flash flooding generates large quantities of water due to poor drainage and low infiltration (Saxton & Rawls, 2006).

In conclusion the causes of flash floods in the area were clearing of vegetation, climate change, topography, unsustainable farming practises, overstocking and siltation.This supported by the evidence provided in this study. Also contributed by over flooded rivers, over flooded lakes and over flooded ponds. The null hypothesis that there are no significant causes of flash floods was rejected

4.4 Effects of Flash Floods

The specific objective was to establish the perceived effects of flash floods in Marigat Sub-County. The objective was realized by asking the respondents' agreement on effects of flash flooding to certain parameter. The status on effects of these variables was rated on a five point Likert scale. The responses were analysed and presented in table 4.11.

4.4.1 Effects of Flash Floods on Environmental Resources

The researcher sought to find out the effects of flash floods on the environment and its resources including but not limited to human, animals, crops, soil and infrastructure. The status of effects on this variable was rated on a five point Likert scale. The responses were analysed and presented in table 4.11.

Table 4.11: Effects of flash floods

	Partly Agree		Agree		Neutral		Disagree		Strongly Disagree		X^2	$p>x^2$
Environmental resources	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**	**Freq.**	**%**	**Freq**	**%**		
Loss of human life	7	3	273	88	20	7	1	0	6	2	905.353	<.0001
Destruction of social amenities	2	1	270	86	21	7	15	5	3	1	871.941	<.0001
Death of animals	10	4	294	94	2	1	3	1	-	-	807.942	<.0001
Destruction of crops	64	20	245	79	1	0	2	1	-	-	513.733	<.0001
Destruction of roads	63	20	246	79	3	1	-	-	-	-	314.058	<.0001
Soil erosion	7	2	296	97	3	1	1	0	-	-	821.638	<.0001

Table 4.11 shows the effects of flash floods losses incurred in the study area during flash flood occasions. Majority of the respondents agreed that flash floods causes soil erosion 97% at chi square 82.638 with a p-value = 0.001 which is less than 0.05 significant level. This means that the flash floods effects significant causes soil erosion in the study area. Refer to appendix V11 plate three. A study that faster moving water on a bare ground transports soil down slopes (Frankl *et al.*, 2016). 94% were in agreement that flash floods causes death of animals at chi-square 807.942 with a p-value = < .0001 meaning that flash floods causes death of animals. According to Kappelman, J. Ketcham, R. A. Pearce, S., Todd, L. Akins, W. Colbert, M. W.Witzel, A. (2019), Animals are covered by muddy and soils leading to death or kills the young ones, 88% were in agreement that flash flood causes loss of human life at chi-square 905.358 with p-value =0.0001,meaning flash floods causes loss of human life and 86% were in agreement that flash floods lead to loss of social amenities including hospitals and schools; at chi-square 871.941 with a p-value =0.0001 refer to appendix VII plate five. This means that flash floods causes destruction of social amenities. On the statement that flash flood destroy crops the respondents agreed,79% agreed that as evident in plate four in appendix VII. The roads getting destroyed by floods was agreed by 79% of the respondents and, 79% of the respondents agreed that flash floods result to soil erosion in the area.

According to key informants, there were losses incurred by farmers during the flash flood which occurs in fast speed. Communities with less self-regulatory measures are highly affected by the effects of the flash floods. According to a study conducted in Kisumu on community perception on flood risks in Nyando district, the effects of flash flood such as loss of livelihood, change in ecosystem and loss of plant and animal lives are felt by the poor members of the society (Okayo, Odera, & Omuterema, 2015). Further, it was evident through field observation that, people living within the study area were subjected to abject poverty. There were no self-regulatory measures in place for the community members to adjust themselves from the floods.

Moreover, according to focus group discussion, it was reported that, flash floods always affected their lives, animals, farms and infrastructure exemplified by the chiefs' office been abandoned due to flash floods (refer to appendix VII plate number six). Ng'ambo secondary school had to be moved in 2013 since the place was inaccessible. This problem has always caused them to lose property every year as a result of damages encountered. They appreciated Red Cross for the house they have built for the affected families and were hesitant that the county government were seen during the time of problem and thereafter do not provide a long term solutions.

In conclusion, it was found out that the flash floods causes effects that includes damages, destruction of lives, crops, property and environmental resources and therefore the null hypothesis that there are no significant perceived effects of flash floods in Marigat Sub-County was rejected.

4.5 Mitigation Strategies of flash floods

The third objective was to determine mitigation strategies of flash floods management in Marigat Sub-County. The researcher was interested in knowing whether there were any clear mitigation strategies. The objective was realized, through asking respondents if they were aware of any mitigation strategy and the results were as shown in the table below 4.12-4.17.

4.5.1 Flash Floods Mitigation Measures

The study sought to identify the flash floods mitigation measures. The results are presented in table 4.12 below.

. **Table 4.12: Mitigation measures**

Mitigation measure	Very often		Often		Rarely		Not at all		I don't know			
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	X^2	$P>X^2$
Cash transfers	4	1.3	44	14.33	127	41.37	117	38.11	15	3.81	214.0912	<.0001
Humanitarian aid	153	49.35	76	24.52	59	19.43	22	7.1	-	-	117.7419	<.0001
Traditional warning	41	13.36	64	20.85	74	24.1	105	34.2	23	7.41	64.44495	<.0001
Building of bridges	3	0.94	60	19.67	145	47.54	84	27.71	13	4.26	217.2789	<.0001

Table 4.12 above illustrates mitigation measures provided to flash floods affected households. It was noted that the majority of the respondents agreed that often the supply of humanitarian aids was experienced 49%. According to Owuor (2015) humanitarian aid was provided by Non-governmental organizations like Red Cross and AMREF by the provision of clothing and food. This strategy was un-attainable due to increased population and regular occurrence of the disaster. Residential houses build by Red Cross to residence of Illing'arua location constructed in high raised grounds to prevent flash floods water inundation (refer to appendix VII plate number 7). This was the Non-Governmental organisation that the community felt supported them during the time of flash floods (Deichsel, 2019b). The second significant management strategy was traditional warning 13% where the community used traditional knowledge to predict occurrence of flash floods. Additionally, cash transfer has been availed to victims of flash floods to cushion them from the flash flood impacts. 1% of the respondents agreed that there was cash transfer offered to the victims, According to research cash transfer was found to be unsustainable as far as mitigation measures is concerned (Suroso *et al*., 2018), finally the building of bridges to facilitate movement during flash flooding was agreed by 1% of the respondents.

Other mitigation strategies that the respondents gave during the field study were 70% construction of barriers along the river banks helped in managing flash floods. Construction of Gabions supported by 20% and evacuation was agreed by 10% of the respondents.

Further, according to field observation, gabions along Perekera River have been constructed to prevent the study area from flash floods. The gabions helps in channeling the water into the Lake Baringo rather than to the surrounding area. This therefore, helps in preventing and protecting neighbouring communitues from flash floods and its effects.

According to focus group discussion, the mitigations strategies available in the study area was not sufficient except for traditional knowledge that the resident were using to gap there recurrent problems in the environment. Implemtation of policies by the government was not done and only seen during occurrence of disasters and there after do not follow up to ensure compliance. The focus group discussion recommended that the government to look for better management strategies of prospolis species which have change the water ways and creation new channels after blocking the original water way.

4.5.2 Encounter with Flash Floods

The study sought to identify how often the flash floods occurred in the area. Therefore, respondents were asked whether they have had an encounter with flash floods. The results have been presented in table 4.15 below.

Table 4.13: Encounter with flash floods

Encounter	Frequency	%	X^2	$p>x^2$
I don't know	3	1.15		
Not at all	9	3.44		
Often	169	64.5	403.0542	<.0001
Rarely	79	30.15		
Very often	2	0.76		

According to table 4.15, majority of the respondents at 65% agreed that they were often affected by flash floods, 30% were rarely affected by the flash floods and 1% were very often affected. On the contrary 3% of the respondents agreed that they had no experience of flash floods and 1% did not know anything about the experiences of flash floods. The study found that there is significant association between the residence information on the flash flood and the occurrence of flash flood since the chi square was 403.0542 with a p-value = 0.0001 which was less than 0.05 significant level. This enable residence desire to have a better mitigation strategies to solve the recurrent issue (Lazrus, Morss, Demuth, Lazo, & Bostrom,

2016). The often effects of flash floods in the study area as proved by the responses means that there is need to ensure remedial mitigation strategies are essential.

4.5.3 Traditional Ways of Predicting Flash Floods in the Area

The study sought to find out the signs of upcoming flash floods in the area. The findings are as shown in table 4.16 below.

Table 4.14: Traditional methods

Methods	Frequency	Percent	X^2	$P>X^2$
Animal behaviour	3	1.21		
Clouds and rainfall	187	75.71		
Shape of the moon	7	2.83	640.7328	<.0001
Sheep intestines	7	2.83		
Use of stars and heavenly bodies	38	15.38		
Wind direction and temperature	5	2.02		

Table 4.14 shows that the respondents were aware of traditional signs which were used. The study found that there is significant knowledge on the traditional ways of predicting heavy hence the flash flood since the chi square was 640.7328 with a p-value = 0.0001 which was less than 0.05 significant level. The majority 76% agreed that clouds and rainfall were common methods used. The use of stars and heavenly bodies was agreed by 15% of the respondents while 6% agreed on the use of sheep intestines and shape of the moon. Wind direction and temperature was supported by 2% respondents while animal behaviour were supported by 1%. According to Nyakundi, Mogere, Mwanzo & Yitambe (2010), traditional mitigation measures assists in the management of flash floods in the world. It has been practiced by communities to gap problems associated with flash floods. Adaptation of local culture and environment in management of flash floods has been embedded in community practices, institutions, relationships, and rituals, to avoid the adverse effects of the calamity (Macnight Ngwese, Saito, Sato, Agyeman Boafo, & Jasaw, 2018). This facilitate emergency preparedness by the communities living in the study area.The study area have relied in this method despite it have not address fully their concern of flash floods.

4.5.4 Duration Taken after the Onset of Rains for the Flash Floods to Occur

The study sought to identify the duration which the flash floods occur in the area. The results are tabulated in table 4.17 below.

Table 4.15: Duration Taken after the Onset of Rains for the Flash Floods to Occur

DURATION	Frequency	Percent	X^2	$P>X^2$
After 15 minutes	119	66.48	277.4413	<.0001
After 20 minutes	45	25.14		
After 30 minutes	5	2.79		
After one hour	3	1.68		
After a weeks	7	3.91		

On the time it takes from when the signs are observed to when the flash flood is experienced, table 4.15 indicate that the majority of the respondents were in agreement that the flash floods occur after 15 minutes at 67%. This proved that flash floods occurrence is immediately after rainfall therefore, it does not give time for preparation of calamities (Liu *et al*., 2018) , 25% of the respondents asserted that the flash floods take 20 minutes to occur, 4% after 30 minutes, 3% after one hour and 2% after one week. The study found that there is significant association between the duration taken for flash flood to occur and the time after the onset of the rain since the chi square was 277.4413 with a p-value = 0.0001 which was less than 0.05 significant level. Flash floods phenomena destroys a number of environmental resources and requires urgent attention since occurances is faster in that preparation time is minimual,This calls for all stakeholder to collective thinking and discussion to enable address the problem.

4.5.5 Signs of Flash Floods

The study sought to find out the signs of flash floods in the study area. The results have been tabulated in table 4.16 below.

Table 4.16: Signs appearance in an area before flash floods occurs.

Appearance	Frequency	Percent	X^2	$P>X^2$
Heavy rainfall in highland around marigat	42	23.08	11.9121	<.0026
Swelling Rivers and Lakes	80	43.96		
Heavy sky showing signs of rains	60	32.97		

Table 4.16 shows that,swelling rivers and lakes were the most common sign at 44%. Rivers' and lakes' swelling indicated flash floods were about to occur. Heavy sky showing signs of rains was at 33% while heavy rainfall in highlands around Marigat were at 23%. This shows

that the study area communities heavily depended on the swelling of rivers and lakes for the prediction of flash floods in the region. The study found that there is significant association between the sign appearance in an area and the occurrence of the flash flood since the chi square was 11.9121 with a p-value = 0.0026 which was less than 0.05 significant level.The signs well elaborate was enough to make the study area residents at all time prepared and able to meet the challenges that is recurrent every year caused by flash floods.

4.5.6 Period taken After Flash Floods Signs Occur

The study sought to find out the duration which the flash floods took to occur. The results are shown in table 4.17 below.

Table 4.18: Period taken After Flash Floods Signs are noticed

DURATION_	Frequency	Percent	X^2	$P>X^2$
After 10 minutes	100	32.36		
Few days	76	24.6		
Immediately	118	38.19	174.0583	<.0001
More than one week	12	3.88		
Not known	3	0.97		

Table 4.17 shows results regarding how long it usually takes from time the signs are observed to when the flash floods are experienced. The results were as follows; 38% respondents agreed that it occurs immediately, 32% were of the opinion that it take 10 minutes, 24% agreed that it takes a few days while 4% of the respondent said one week. However, 1% did not know how long it took for the actual occurrence of the flash floods. The study found that there is significant association between the duration taken for flash flood to occur and the time the signs are noticed since the chi square was 174.0583 with a p-value = 0.0001 which was less than 0.05 significant level. The periods are very short that calls for residents, County government, National government and Non governmental organisation move faster and provide ways and means to address this environmental challenge of flash floods. The multi-sectorial consolidation of various mitigation strategies address this environmental concern.

In conclusion the mitigation strategies currently employed in the study are insufficient and can not address the environmental concern then, the null hypothesis that, there are no significant mitigation measures is therefore accepted.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introductions

This chapter presents the summary of the research findings, conclusions, recommendations, policy recommendations and further research areas as per the research objectives from this study.

5.2 Summary

This section presents the summary of the findings. The summary of the findings are guided by the study objectives and they are presented below.

Objective one was to determine the cause of flash floods in Marigat Sub- County and the respondents reported that the events that cause flash floods as follows, clearing of vegetation, 53 percent strongly agreed, 25 percent agreed, 12 percent disagreed, 6 percent strongly disagree and 4 percent were not aware of the cause. Regarding to climate change 51 percent strongly agreed, 11 percent agreed, 29 percent were not aware, 7 percent disagreed and 2 percent strongly disagreed. Respondents strongly agreed that land topography causes flash floods 48 percent, 36 percent agreed, 15 percent did not know and 1 percent disagreed. Also unsuitable farming practise causes flash floods were 55 percent strongly agreed, 31 percent agreed, 10 percent were not aware and 4 percent disagreed.

In conclusion the causes of flash floods in the study area were clearing of vegetation, climate change, topography,unsustainable farming practises and siltation. Also contributed by over flooded rivers, over flooded lakes and over flooded ponds. The null hypothesis that there are no significant causes of flash floods was rejected.

Objective two was to establish the perceived effects of flash floods in Marigat Sub-County. It was reported flash flooding causes loss of human life by 88 percent of the respondents. Destruction of social amenities from flash flooding was agreed by 86 percent of the respondents, death of animals was agreed by 94 percent, destruction of crops was supported by 79 percent of the respondents, destruction of roads was agreed by 79 percent and finally soil erosion was agreed by 97 percent of the respondents. According to the observation schedule, conducted it was evident that the people living within the study area

were subjected to abject poverty. Poverty has been attributed to poor response during flash floods, it implies that those who are financially able, are able to opt out of flood prone areas with the shortest time possible, following a flood warning, unlike those who have nothing to ferry them out of the flood risk area.

In conclusion, it was found out that the flash floods cause damages and destruction of lives, crops, property and environmental resources and therefore the null hypothesis that there are no significant perceived effects of flash floods in Marigat Sub-County was rejected.

Objective three was to determine mitigation strategies of management of flash floods and the findings showed that the mitigation strategies in the study area were humanitarian aid expressed by 49.35 percent of the respondents while another 13.36 percent agreed that traditional warning systems as a mitigation strategy was used. Cash transfer is critical in enhancing the financial capability of the residents to cope with flash flooding as expressed by 14.32 percent of the respondents. Building of bridges to protect roads from flash floods is an important mitigation strategy to ensure access of the area, 19.62 respondents agreed that there was building of bridges in the study area.

In summary, the findings proved that the study area is suffering phenomenal effects that require urgent attention from all the stakeholders. Since the available mitigation measures are insufficient to mitigate environmental issue, the null hypothesis that, there are no significant mitigation measures is therefore upheldaccepted.

5.3 Conclusions

The study concluded that;

The respondents in the study area are knowledgeable about the causes of flash floods and the timing of the flash floods within their area. However, they do not have enough resilience skills to predict and avoid flash floods, in their areas during heavy rainy seasons.

The effects of flash floods are widely felt among the community members where it has led to loss of life, death of animals, destruction of crops, property (roads and infrastructure) and soil erosion. This problems have led to increased poverty level contributed by massive losses every year.

Mitigation strategies for management are key to averting the effects of flash flooding. The strategies of mitigating flash floods included humanitarian aid meant to reduce the poverty rates and help the community members in building resilience from the effects of flash floods. Cash transfers are also required in order to facilitate the victims to get the basic needs and adjust to the disaster. A formal early warning system is important in predicting of an impending flash flooding, this is an important management tool for mitigation and preparedness by the community. Early warning systems are not found in the area and they depend mainly on crude unreliable traditional methods of predicting floods.

5.4 Recommendations

The following are the recommendation made according to the study objectives;

1. Causes of flash floods: Creation of awareness on the possible mitigation measures to curb flash floods, could help the community members to avert the effect of flash floods. Use of traditional knowledge among the community members to avoid the effects of floods such as building houses on higher grounds.
2. Effects of flash floods: Community participation in afforestation could increase the soil texture; increased afforestation could help in the absorption of runoff water increasing the infiltration rates of water causing flash flood. This can be done through community based organization that easily understands their problems and supports project that will assist them. Further non-governmental organizations are key stakeholders that can assist this communities address there persistent environmental concern of flash floods.
3. Mitigation strategies of flash floods: Implementation of early warning systems and mapping of flash floods in the study area could enhance resilience to early prediction and avoidance of flash floods effects. These help the community members in avoiding the flash flood prone areas during heavy rainy seasons. This is possible when all the

community members are informed of what is likely to happen in rainy seasons that preparedness by having lively hood alternative that include relocations and better used of this environment.

5.4.1 Policy Recommendations

The following policies are recommended to be implemented in the study area. This is because the study shows that the laws and policies have little implementation in the study area. For effective management of floods in the region, the following laws policies need to be implemented in the study area.

Implementation of the Water Act 2002 cap 372, it has a provision for protecting and managing water resources including catchments and prevention of water related risks such as flash floods. The Act explains the importance of gathering accurate data on flash floods related events (Wagah, Onyango, & Kibwage, 2010). It also provides for the acquisition of state resources such as Land use and Forest Acts.

The National Environmental Management Authority (NEMA) created by the Environmental Management and Coordination Act No 8 of 1999 is entitled to prevention of environmental hazards such as flash floods (Arts, Caldwell, & Morrison-Saunders, 2001). This is done through Environmental Impact Assessment that gives guidelines of best practices for management. The Act outlines the need to protect and conserve the environment especially lakes, rivers and wetlands. Therefore river bank and lake shore be protected from vegetation clearance for charcoal and farms in order to increase buffer zones to reduce amount of siltation to the water bodies.

The Local Authority Act Cap. 265 provides for the establishment of a disaster management office in every Local Authority to liaise with central government and its agencies and other organizations that includes non-governmental organizations like Red Cross dealing with disasters such as flash floods. It also identifies special powers on resource mobilization that

may be used in the event of a local disaster have been established within the Act (Mboga, 2009). Disaster management offices should be established in every county and sub-county to help combat both human made and natural disasters such as flash floods. Local Authority Act CAP 265 allows for the establishment of such offices, in order to specialize on resource mobilization in case of a disaster. Therefore Marigat Sub –County needs an office of this status established in Marigat town not to rely in County office located in Kabarnet which is far and response to any incident might be slow.

The forest Act 2016 allows for the protection and conservation of natural and artificial forests (Harrinkari, Katila, & Karppinen, 2016). It mandates the national government, county government and the local communities to protect and preserve the natural forests and its associated water catchment areas to help in reducing the effects of flash floods. A programme of tree planting at county and sub county be planned and implemented every year to enable vegetation cover sustainability be attained in the study area.

5.4.2 Recommendation for Further Research

1. Geospatial mapping and analysis of the flash floods trends in the study area should be conducted, to help in understanding future flash floods.
2. Adaptation measures in responses to climate change effects such as flash floods that includes reforestation programmes established , avoidance of use of herbicides that destroys vegetation covers.
3. An alternative livelihood and economic projects be developed instead of charcoal burning that make the land vulnerable to flash floods when all the vegetation is cleared.

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APPENDICES

Appendix I: Questionnaire

SECTION 1: QUESTIONNAIRE FOR HOUSEHOLD HEADS

I am a student at Kabarak University, Pursuing a Master's programme in Environmental science. I am conducting research on assessment of flash floods occurrence and management in Marigat, Sub-County Kenya. I am kindly requesting for your time in filling in the responses to the best of your knowledge. This research is meant for academic purpose. It will try to find out the causes, effects and management of flash floods in Marigat Sub-County. Responses to these questions will be treated as confidential and used for academic purposes only.

Section A: General information

1. Date of the interview……...

2. County……Sub-county……..

2. Name of respondent……..

4. Gender: a) Male [ ] b) Female [ ]

5. Location ----------

6. Level of education: a) Certificate [ ] b) Undergraduate [ ] c) Postgraduate [ ]

d) PhD [ ] e) None [ ]

7. Age (years): a) 18-25 [ ] b) 26-33 [ ] c) 34-41[ ] d) 42-49[ ] e)

50-57] f) 58-65 [ ] g) 66+ [ ]

Section B: Flash floods Information

1. How many years have you lived or conducted business at this location?

a) One year ☐

b) Two years ☐

c) Between three to five years ☐

d) Above six ☐

2. Does flash floods always occur during all rainy seasons every year in your area?.

a) Yes ☐

b) No ☐

If yes, what type(s) of flooding have you experienced?

	Frequently	Moderately	Not at all	Monthly
Home flash flooding				
Riverbank flash flooding				
Lake flash flooding				
Pond flash flooding				

3. What is the frequency of flash flood occurrence in your area?
    a) Frequently ☐
    b) Once after three months, ☐
    c) Once a year, ☐
    d) After some years ☐
    e) When there is a lot of rain ☐
4. Where did the flooding originate from?

Source	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Over flooded rivers					
Over flooded lakes					
Over flooded ponds					
Over flooded roadways					
Lack of vegetation on land					
Unknown					

5. Did your neighbours or others in your area experience flooding? List names, contact information or list the general location of the flooding.

NO.	INDIVIDUALS WHO USE STRATEGIES OF MANAGEMENT	PHONE NO.	LOCATION
1			
2			
3			
4			
5			
6			

Section C: Causes of flash flood occurrence

6. What are the cause flash floods?

Causes	Strongly Disagree	Disagree	Unknown	Agree	Strongly Agree
Vegetation clearance					
Climate Change					
Topography					
Unsustainable practise					
Overstocking					
Siltation					

7. What are the approximate date(s)/months of flash flooding occurrence? Please tick where applicable.

MONTH	YES	NO	NO SURE
JANUARY			
FEBRUARY			
MARCH			
APRIL			
MAY			
JUNE			
JULY			
SEPTEMBER			
OCTOBER			
NOVEMBER			
DECEMBER			

8. What are the types of events cause flash floods on your property?
   a) Short intense rain, such as thunderstorms
   b) Long moderate rain
   c) Long heavy rain
   d) Other (specify)----------

9. If you know, please describe the type of flash flooding which occurred in the following storm events?

Scale: No Extent (NE), Little Extent (LIE), Moderate Extent (ME), Large Extent (LE), Very Large Extent (VLE). Not Known (NK)

Type of flooding	No extent(NE)	Little Extent(LE)	Moderate Extent (ME)	Large Extent (LE)	Considerable Extent(VLE)	Not known (NK)

10. What is the distance of your property from any potential source of a flash flood?

	Distance
Stream	
River	
Watercourse	
Dyke	

11. Has the area within a 100m radius of the property ever flooded?

a) Yes ☐

b) No ☐

12. . Has the area that the property is situated within ever been subject to a flood alert/warning by the applicable environment agency?

a) Yes ☐

b) No ☐

If yes, identify the agencies

Flash Flood alert	Agency

13. Are there any flash flood defences in place either at your property or in the local area?

Flash Flood Risk Reduction Structures	**Where Located**	**Current Status** (e.g. functional, broken, silted **etc.)**
Water Pans		
Evacuation centres		
Dykes on river banks		
Water drainage channels		

14. Have you registered or signed up to receive flash flood warnings for your area from applicable flood bodies?

Yes ☐

No ☐

Section D: Effects of flash-floods

1. The effects of flash floods to below indicated environmental resources.

Scale: Partly agree, Agree, Neutral, Disagree and strongly disagree

	Partly agree	Agree	Neutral	Disagree	Strongly disagree
Loss of human life					
Destruction of social amenities					
Loss of animal life					
Destruction of animal life					
Destruction of crops					
Destruction of roads					
Soil erosion					

Section E: Strategies of mitigating flash-floods

1. Are you aware of any form of strategies used for mitigating flash floods in your area?
    a. Yes
    b. No.
2. If yes, what are the strategies used in effective management that are used to identify an impending flash flood?

3. How many times have you encountered an individual who uses traditional means to predict flash floods in your locality?

Very often	Often	Rarely	Not at all	I don't know

4. What are the signs of upcoming flash floods in your location?

No.	Signs of upcoming flash floods	Duration before the rains causing floods	Where do the signs appear in your area
A			
B			
C			
D			

5. How long does it usually take from the time the signs are observed to when the flash floods are experienced?

a) No known ☐
b) More than one week ☐
c) After 10 minutes ☐
d) Immediately ☐
e) Few days ☐

6. What are the mitigation measures that have access to in your area?

Mitigation measures	Very often	Often	Rarely	Not at all	I don't know
Cash transfers					
Humanitarian Aid					
Traditional warning					
Building of bridges					

Appendix II: Focus Group Discussion Guide

1. Location----------
2. Number of people in attendance ----------
3. Is the local community aware of flash flood occurrences?
4. At the residence ready to face this natural disaster if it occurs?
5. What are the types of natural disasters known in the area?
6. What are the causes of flash floods in the area?
7. What are the effects of flash floods on the economy of the area?
8. What are the strategies used in mitigating flash floods within your community?
9. Is the community responsive in management of flash floods?
10. What are the contributions of the government on the problem of flash floods?

Appendix III: Key Informants Interview Guide

1. Location----------
2. Number of people in attendance ----------
3. Is the local community aware of flash flood occurrences?
4. At the residence ready to face this natural disaster if it occurs?
5. What are the types of natural disasters known in the area?
6. What are the causes of flash floods in the area?
7. What are the effects of flash floods on the economy of the area?
8. What are the strategies used in mitigating flash floods within your community?
9. Is the community responsive in management of flash floods?
10. What are the contributions of the government on the problem of flash floods?

Appendix IV: Observation checklist

1. Location----------
2. Date ----------
3. Terain of the area, Flat / slopy
4. Soil eroision Yes/No
5. Are there social amenities destroyed Yes/No.
6. In case of flash floods is all the area likely to be affected Yes/No
7. Are there some control measures see in the area? Yes/No
8. Which are the infrustructures affected by flash floods? Roads/schools/Homes/medical facilities/ playing ground among others.
9. Are there abandoned areas/infrustucture due to flash floods?

Appendix IV: Letter of Introduction

KABARAK UNIVERSITY

Private Bag - 20157
KABARAK, KENYA
http://kabarak.ac.ke/institute-postgraduate-studies/

Tel: 0773 265 999
E-mail: directorpostgraduate@kabarak.ac.ke

BOARD OF POSTGRADUATE STUDIES

4th July, 2019

The Director General
National Commission for Science, Technology & Innovation (NACOSTI)
P.O. Box 30623 – 00100
NAIROBI

Dear Sir/Madam,

RE: JULIUS KIPKEMOI KIPTIM- REG. NO. GMEN/NE/0205/01/18

The above named is a Masters of Environmental Science student at Kabarak University in the School of Science, Engineering and Technology. He is carrying out research entitled ***"The causes, effects and Management of Flash Floods in Marigat Sub- County, Baringo County, Kenya"***. He has defended his proposal and has been authorized to proceed with field research.

The information obtained in the course of this research will be used for academic purposes only and will be treated with utmost confidentiality.

Please provide him with a research permit to enable him to undertake his research.

Thank you.

Yours faithfully,

KABARAK UNIVERSITY DIRECTOR POST GRADUATE STUDIES 04 JUL 2019 PRIVATE BAG - 20157, KABARAK

Dr. Betty Jeruto Tikoko
DIRECTOR, POSTGRADUATE STUDIES

Appendix V: Permits
NACOSTI Licence

THIS IS TO CERTIFY THAT:
MR. JULIUS KIPKEMOI KIPTIM
of KABARAK UNIVERSITY, 0-20157
Kabarak,has been permitted to conduct
research in *Baringo County*

on the topic: *THE CAUSES, EFFECTS AND MANAGEMENT OF FLASH FLOODS IN MARIGAT SUB-COUNTY, BARINGO COUNTY, KENYA.*

for the period ending:
19th August,2020

.....
Applicant's Signature

Permit No : NACOSTI/P/19/70554/31912
Date Of Issue : 20th August,2019
Fee Recieved :Ksh 1000

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

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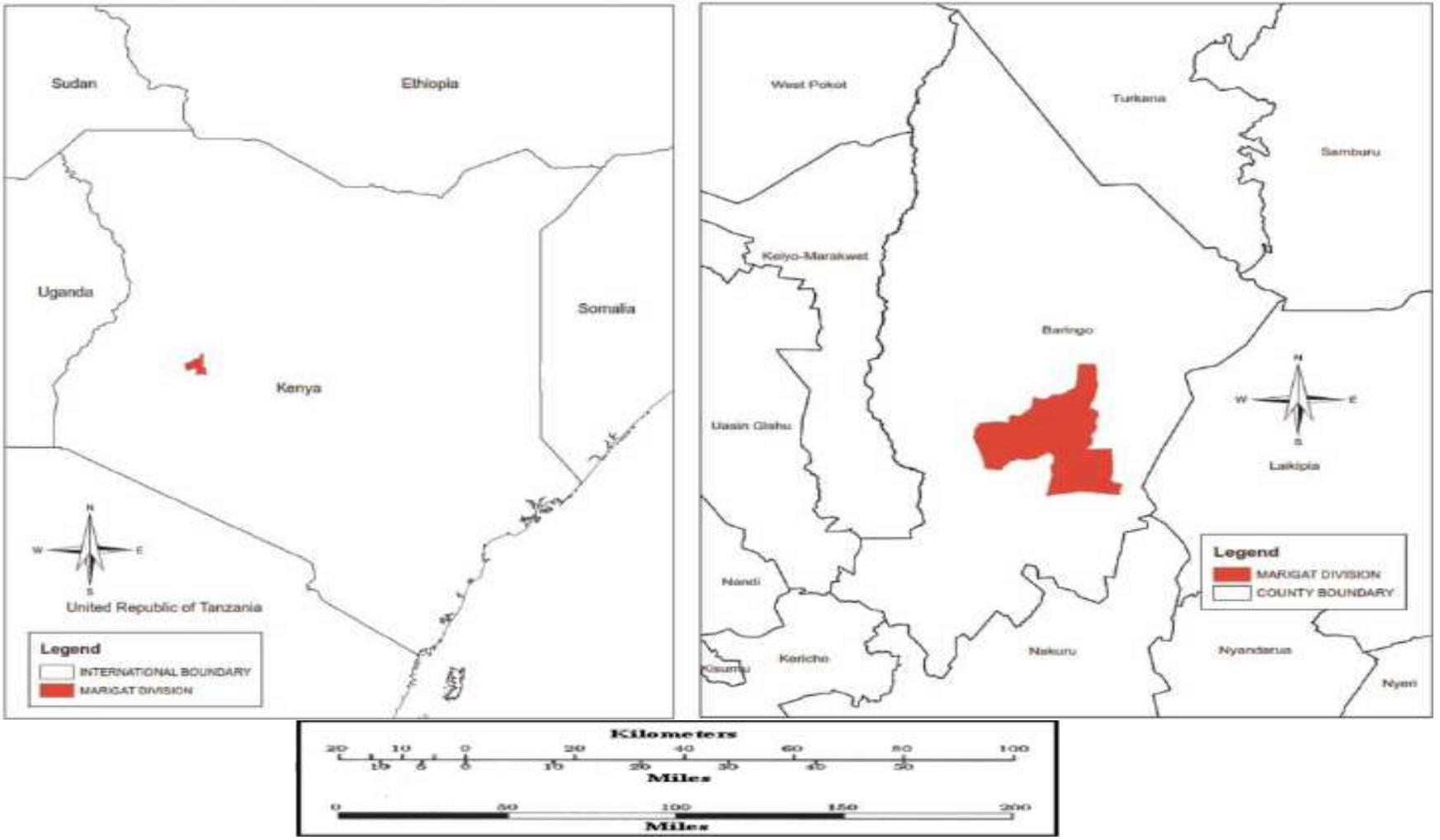
Appendix VI: Map Of Study Area



Appendix VII: List of Study Plates

Plate 1: Focus group discussion in Ilingarua Location

Plate 2: Flash floods in Ng'ambo location

Plate 3: Soil erosion in Salabani location

Plate 4: Destruction of crops by flash floods in Salabani Location

Plate 5: Soil erosion in Former Salabani primary school

Plate 6: Ng'ambo chief's office vacant due to flash floods

Plate 7: House constructed by Red Cross