

**EXTENT OF USING NON-STRUCTURAL FLOOD CONTROL MEASURES AND
THEIR IMPACT ON HOUSEHOLD WELFARE IN BUNYALA SUB-COUNTY, BUSIA
COUNTY, KENYA**

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**A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirements for
the Master of Science Degree in Agriculture and Applied Economics of Egerton University**


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OCTOBER, 2024

DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented in this university or any other for the award of any academic certificate diploma or degree

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Recommendation

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DEDICATION

I dedicate this work to my daughter Agatha Njeri for being a source of inspiration and hope.

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ABSTRACT

Floods are the most destructive water-related disasters considered to have dire consequences to the livelihoods of the affected population. Kenya experiences both riverine and flash floods in various parts of the country and various measures have been devised to deal with floods. Structural measures; dykes, canals, reservoirs, and non-structural measures: early warning systems, insurance schemes, awareness campaigns, and land-use planning have been implemented as mitigation measures to help in coping with this disaster. Structural measures often require large investments hence these measures are mainly implemented by the government. Non-structural measures can however be implemented by various parties such as individuals and non-governmental organizations in their various capacities. This study focused on four non-structural measures namely; Flood forecasting and Early Warning Systems (FEWS), land-use planning with zoning, rainwater harvesting, and self-insurance, implemented in flood-prone Bunyala, Busia County in Kenya. Although these measures are in use, there is no clear evidence of the impact it has on the livelihoods of vulnerable households. To fill this gap, the main objective of this study was to contribute to the welfare of households in Bunyala Sub-County. The specific objectives were to determine the household perception, factors influencing the extent of use, and welfare impact of non-structural flood control measures. A multistage sampling procedure was used to obtain the desired sample of 384 with 256 participants and 128 non-participants. Descriptive statistics were used to analyze the household perception. Multivariate Multiple Regression model was used to determine factors influencing extent of use and Propensity Score Matching (PSM) was used to determine the welfare impact of non-structural measures. The descriptive results indicated that land-use planning with zoning was perceived more useful compared to the other measures due to its ease of application. Multivariate regression showed that Early Warning duration, flood frequency, flood effect, land regulation awareness, credit access, climate information access, receiving early warning, saving for floods, and water harvesting initiatives were factors found to be jointly significant in influencing the extent of using the non-structural flood control measures at $p < 0.05$. PSM results revealed that participants spent Ksh. 3860.7 less consumption expenditure compared to participants. It was therefore concluded that the flood control measures had a positive impact on welfare. Policy implications included improving early warning technology and building awareness. Households need to come up with initiatives aimed at creating awareness and sharing the right information on floods and non-structural measures.

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LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|----------|---|
| APFM | Associated Programme on Flood Management |
| ATE | Average Treatment Effect |
| ATT | Average Treatment Effect on Treated |
| CBOs | Community-Based Organizations |
| FEWS | Flood Early Warning System |
| FWDC | Flood Warning and Dissemination Centre |
| GoK | Government of Kenya |
| KIWASH | Kenya Integrated Water, Sanitation and Hygiene |
| KMD | Kenya Meteorological Department |
| NGO | Non-Governmental Organization |
| PSM | Propensity Score Matching |
| SDGs | Sustainable Development Goals |
| UNDP | United Nations Development Programme |
| UNDRR | United Nations office for Disaster Risk Reduction |
| WKCDD&FM | Western Kenya Community-Driven Development and Flood Mitigation |
| WMO | World Meteorological Organization |
| WRMA | Water Resources Management Authority |
| WRUA | Water Resources Users Association |

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Floods is a water-related disaster that accounts for 54% of all water-related disaster globally and 23% in Africa (Perera et al., 2019). Flooding may be a result of torrential rainfall or manipulation of catchment areas. Activities such as deforestation and upstream land degradation may cause excess surface water run-off hence flooding. Floods in their most immediate effects cause destruction of property and infrastructure, loss of lives, displacement of people, and disruption of socioeconomic activities (Opere, 2013). Secondary effects associated with floods include the outbreak of water and vector-borne diseases during and after floods, loss of income, disruption, and setback of ongoing developments programs, and disruption of normal family life (Opere and Ogallo, 2006). Poor households suffer the most since they rely on short-term strategies that are not sustainable and cannot adapt to long-term measures (Opondo, 2013b).

In Kenya, climate variability is commonly influenced by the complex and varied topography, altitude, lake, and sea breeze. Additionally, the complex tropical climate varies significantly between regions due to regional climatic processes such as migration of the Inter-tropical Convergence Zone (ITCZ) (Kiptum, 2019). Approximately 50,000-150,000 people have been affected annually by floods in the past decade (World Bank, 2019). Major flood events that have occurred in Kenya have been documented. The 1961 floods represent one of the early attempts of studies initiated to measure the extent and magnitude of the menace. Low-lying areas were extensively inundated and widespread damage to homesteads, bridges, and other facilities was experienced (Conway, 2002). The 1997/1998 El-Nino floods was one of the most devastating flood events in Kenya. This flood in its direct effects saw displacement of households, destruction of infrastructure and extensive crop and livestock losses. Additionally, land degradation, soil erosion, and outbreak of waterborne diseases increased significantly during this period (Ngecu & Mathu, 1999). In the April/May 2003 Budalangi and Nyando floods, homes, schools and farms were completely submerged; data loggers, water level recorders, bridges, and river gauging structures were carried away, and thousands of people displaced. Other noteworthy events are in years, 2008, 2012, 2015/2016, 2018, 2020. Over the years, flooding frequency has increased and ranges between 2-5 years (Owuor & Mwiturubani, 2021).

Measures taken to mitigate the effects of floods have been categorized into structural and non-structural measures. Structural measures include the construction of reservoirs, dykes, diversion channels, and spillways among others. Non-structural measures include flood early warning systems, public education and awareness campaigns, flood insurance schemes, land-use planning and zoning, and rainwater harvesting (World Meteorological Organization (WMO), 2013). Structural measures are meant to reduce the effects of the flood hazard and more inclined to modify the environment through construction. These measures are however associated with residual risks due to the possibility of failures from the structures. Non-structural measures are meant to manage vulnerability hence essential to eliminate residual risks and have different implementation periods, namely, prior, during, and post-flood occurrences (Babić, 2015). This study focuses on non-structural measures before a flood event.

Busia County, especially Bunyala Sub-County in Western Kenya has been one of the most flood-prone areas in Kenya. It is located in the lowland region of River Nzoia Basin. Floods in this region could be attributed to the activities in the highlands that increase water surface run-off. The breaking of dykes and river backflow has also aggravated the situation. Despite the floods, the main economic activity in Busia County is agriculture, which serves as the backbone of the county's economy. The majority of the population engages in subsistence farming, with small-scale farming being predominant. Crop farming is done for staple foods such as maize, beans, cassava and sweet potatoes; which are primarily for household consumption with some surplus sold in local markets. Livestock keeping entails mainly poultry which supplement the dietary needs of the households as well as supplement incomes (County Intergrated Development Plan (CIDP), 2023). Other economic activities include small-scale businesses such as retail shops and market trading of mainly agricultural produce. Also due to proximity to Lake Victoria, households participate in fishing. Agriculture in Busia County in a major way contributes directly or indirectly to household welfare. Income earned from selling farm produce or being employed in farms improves welfare by catering to the consumption expenditure. Indirectly, agriculture improves household welfare through providing nutritious food for consumption hence improved health and productivity in daily economic activities (Kenya National Bureau of Statistics, 2021).

Households have been surviving with the effects of floods by employing short-term coping strategies such as relocating to emergency settlements and relying on structural measures only; which has proven unsustainable due to the observed high poverty rates. However, over time,

households in Busia County have embraced non-structural flood control measures to complement structural measures for the effects to be adequate. These measures include Flood Forecasting and Early Warning Systems, land-use planning and zoning, rainwater harvesting, and Savings and credit scheme (Opere & Ogallo, 2006; Otieno, 2010).

Flood forecasting and early warning systems (FEWS) is a tool that covers flood levels, likely impacts of a flood, disseminating warning messages as well and reviewing the effectiveness of the system following an event. There are significant numbers of institutional initiatives currently active in the African continent. Information regarding many of these initiatives is not publicly accessible, which results in underestimation by the wider scientific community of the amount of flood forecasting activity undertaken in the continent (Thiemig et al., 2011). In 2008, the Western Kenya Community-Driven Development and Flood Mitigation (WKCDD&FM) Project was initiated by the Kenyan government with support from the World Bank to address flooding problems. This project collaborated with the Kenya Meteorological Department (KMD) which took to establishing the Flood Early Warning Systems (UNISDR, 2015).

The FEWS developed was motivated by experiences from the Lake Victoria basin' which recommended the integrated flood management approach. It was reported that in the 2011 flood events, there were no casualties in Bunyala Sub County as communities were warned early enough. Additionally, 1 million USD is saved annually as a result of the flood mitigation policies that were implemented. However, a picture of policy influence at the household level is lacking.

Land use planning involves regulating how land is used and zoning endangered resources to ensure efficient resource use and desirable environmental outcomes. Environmental degradation especially land through deforestation, sand harvesting, and farming along the banks and pollution of watershed catchment areas are features that make communities in Bunyala more vulnerable to floods (GoK, 2010).

Water harvesting is among the measures earmarked for support by KIWASH through WRUAs in Busia County through the construction of water intakes, storage tanks, distribution pipelines, and pumping systems. Additionally, the program was envisaged to support capacity building among stakeholders to ensure that households benefit through access to water and awareness creation on the protection of water sources (USAID, 2018). Households in Busia County have embraced small-scale water harvesting which involves redirecting, storing, and capturing rainfall, runoff, and groundwater (MoALF, 2018).

Owing to the risks of floods of people residing in Busia County and the possibility of destruction of crops, livestock, and homesteads there is a need for some form of insurance. This enables households to be less vulnerable to future poverty as they can smooth their consumption in the presence of shocks and bounce back after the disaster through individual claims in case of floods. Insurance policies set in Busia County are known by very few and additionally, they would not be able to afford it. Households are therefore largely engaged in savings and credit schemes as a way of insurance from floods through engagement in social groups and cooperatives (Otieno, 2010).

1.2 Statement of the problem

Given the magnitude of the disaster from floods in Busia County, multiple agencies have come into play with alternative mitigation strategies. The strategies that directly engage the participation of the community are non-structural, which include flood forecasting and early warning systems, land-use planning with zoning, savings and credit schemes, and rainwater harvesting. Despite the notion that non-structural measures are considered sustainable, households in Bunyala sub-county still experience negative impacts of floods. It is, therefore, of interest to establish the perception of households and their extent of use of non-structural measures in the sub-county. Further, little is known of the welfare benefits derived or losses incurred by households through the use of non-structural measures. Previous studies have mainly focused on challenges militating against the measures as economic, technological, ability to cope and adapt, level of on-and off-farm income. The study aims to bridge this knowledge gap.

1.3 Objectives of the study

The general objective was to contribute to the welfare of households by providing insight into non-structural flood control measures hence influencing policy toward better flood management in Bunyala Sub-County.

Specific objectives

- i. To establish the perception of households on non-structural flood control measures in Busia County, Bunyala sub-county.
- ii. To determine the extent and factors influencing the extent of using non-structural flood control measures among households in Busia County, Bunyala sub-county.

- iii. To determine the impact of non-structural flood control measures on household welfare in Busia County, Bunyala sub-county.

1.4 Research questions

- i. What is the perception of households concerning non-structural flood control measures in Busia County, Bunyala sub-county?
- ii. What is the extent and what are the factors influencing the extent of using non-structural flood control measures by households in Busia County, Bunyala sub-county?
- iii. What is the impact of the non-structural measures on household welfare in Busia County, Bunyala sub-county?

1.5 Justification

Flood mitigation plays a vital role in protecting livelihoods, property, and infrastructure of vulnerable communities and promoting sustainability. The impact of floods in the county cuts across the SDGs namely 1: No poverty; 2: Zero hunger; 3: Good health and well-being; 4: Quality education; 6: Clean water and sanitation. Achievement of this goal has proved difficult since the flood impacts weigh heavily on rural households (Echendu, 2020).

In disaster risk reduction, the Sendai Framework which acknowledges the importance of reducing the impacts of disaster on society and economy was established and also acts as a lens in the achieving of the sustainable goals. There are 25 targets related to disaster reduction in 10 of the sustainable goals hence establishing the role of risk reduction as a core development strategy. The global targets and priorities for action set in the framework substantially contribute to the achievement of the SDGs and targets through its stronger focus on resilience building (UNDRR, 2015).

This study made insights into government institutions on awareness and extent of use of non-structural strategies, consequently, assisting them to identify loopholes and areas of improvement to realize households' welfare improvement. Determining the impact would also help stakeholders make informed decisions to improve household welfare. The findings will form a basis for policy formulation that will assist the government on whether to continue investing in these programs, change strategies, or divest its funds into other initiatives. Non-Governmental Organizations (NGOs) and Community-Based Organizations (CBOs) will be able to get informed

on the impacts and channel available resources and this will go a long way in helping to make decisions in the quest to promote the welfare of rural communities.

1.6 Scope and limitation of the study

The study was carried out in Busia County, Kenya. The sample unit consisted of households that have resided in the area for at least five years and hence experienced a couple of flood events. Both participants and non-participants were involved in order to determine the impact of non-structural measures. This study focused on measures used before the flood event. One limitation is that the data was based on the opinions and perspectives of the participants hence reliance on recall. To solve this, open-ended questionnaires were used to enhance clarification of questions and probing of accurate responses. Another limitation was obtaining the control group, hence the study made use of information obtained from the county with the help of chiefs and assistant chiefs.

1.7 Operational terms

Non-structural measures-a set of mitigation measures that are not based on physical large-scale defenses.

Risk-the probability that exposure to a hazard will lead to a negative consequence.

Hazard-a source of potential damage or harm to property, human lives, or the environment.

Exposure-it is an area's predisposition to an event due to its location

Vulnerability-the characteristics or conditions that increase the susceptibility of a community to the impacts of a hazard. This could be social, physical, economic and environmental.

Mitigation-actions meant to minimize possible impacts of an undesirable event.

Adaptation measures are meant to reduce vulnerability to the effects of an undesirable event.

Resilience-the capacity of a system to endure a hazard and maintain significant levels of organization in its social, physical, environmental, and economic components.

Disaster risk management-application of disaster risk reduction policies and strategies to prevent new disaster risks, reduce existing disaster risks, and manage residual risks.

CHAPTER TWO

LITERATURE REVIEW

2.1 An overview of flood management

A comprehensive approach to disaster management should include four basic phases: preparedness, mitigation, response, and recovery. Although most countries are focused on the last two phases, the greatest potential for minimization of economic losses and reduction of disaster vulnerability, especially among low-income groups typically lies with preparedness and mitigation (Abbas et al., 2015; Mohit & Sellu, 2017).

Flood disaster management is a multifaceted approach. It involves several disciplines such as public policy and planning, economics, statistics, hydrology, and psychology among others. This is because of the impacts it has on the socio-economic livelihoods of people it affects directly or indirectly (Hill et al., 2023) . Most of the measures resorted to by affected communities are of a preventive or corrective nature intended to minimize damage caused by floods (Shibia, 2020). Structural measures such as the construction of river channels and embankments can provide protection only to the level of the expected flood. Non-structural measures are therefore considered complementary to structural measures because of the potential for synergistic enhancement of their effectiveness. However, non-structural measures may also be used alone if structural measures are not considered feasible and depending on the condition of the river basin as they may be more cost-effective (Salim et al., 2024).

Non-structural flood control measures encompass a diverse range of strategies that focus on managing and reducing flood risk through methods other than physical infrastructure. This literature review explores the key concepts, challenges, and benefits associated with non-structural flood control measures practiced in Busia County.

Land Use Planning and Zoning

Land planning involves the systematic organization and development of land resources to achieve specific goals, such as sustainable growth, environmental conservation, and efficient land use. Zoning is a key component of land planning, where areas are designated for specific types of land use to regulate and guide development (Der Sarkissian et al., 2022). Land use planning and zoning represent crucial non-structural measures in flood control. Hudson and Botzen (2019) emphasized the importance of adopting land use policies that restrict development in flood-prone

areas. Proper zoning can contribute to reducing exposure and vulnerability by guiding urban growth away from high-risk zones, ultimately minimizing potential flood damages.

As a border county with a rapidly growing population and a mix of agricultural, commercial, and residential land uses, Busia faces unique challenges and opportunities in land use planning. The county seeks to increase food security and economic growth, therefore, the focus has been on protecting agricultural land from being converted to other uses while promoting sustainable farming practices. The county also encouraged the adoption of modern agricultural techniques, irrigation schemes, and the diversification of crops to boost productivity (Onyango et al., 2021).

Flood Early Warning Systems

Effective early warning systems play a pivotal role in reducing the impact of floods. Research by Fakhruddin et al. (2015) highlighted the significance of advanced monitoring technologies and communication systems in providing timely and accurate flood forecasts. The success of early warning systems lies not only in technological advancements but also in the formulation of clear evacuation plans and community engagement strategies.

In western Kenya, a flood forecasting early warning system was developed to provide forecasts that would prompt households to act on time and respond accordingly. This system consists of four components that complement each other in ensuring that the system is complete and effective. These components are explained as follows:

Risk knowledge: this involves the systematic assessment of risks and hazards; mapping their trends and patterns. Upon understanding these risks, weather and river gauging stations are established considering the basin's topography, geology, and soils (World Meteorological Organization (WMO), 2013). There are 3 synoptic stations in the Nzoia basin, 16 hydrometric systems, 3 rainfall stations, and 3 radar water level stations (Maina, 2008).

Monitoring and warning system: This involves establishing sensors measuring water levels at relevant sites in local waterways and linking them to the local database. This system consists of data collection, observation and rapid communication system, processing, analysis, and database management systems. This center should be operational 24 hours a day, 7 days a week all year round; and have skilled personnel in hydrology and hydrometeorology and advanced meteorological telecommunication facilities to ensure access to data (UNEP-DHI Partnership et al., 2017).

Dissemination and communication: Information is then disseminated to the dissemination center from where it is distributed to the target population and stakeholders. In Kenya, the Flood Warning and Dissemination Centre (FWDC) is responsible for this function. In the Nzoia basin, some users of this information include the public, the Bunyala community, and Emergency management like the REDCROSS, the government sector, the private sector, and civil societies among others. Some methods used to convey information include emails, internet websites, weather radio, and mobile short messages among others(Otieno et al., 2019).

Response capability: Response plans by the communities and forecast review and development are also included in the components of EWS. It is important to have training and communication centers to create awareness and enhance preparedness. Communities are expected to also keep watch of the rainfall and water levels, provide indigenous information that can be integrated into EWS, provide flood information, provide information on the impacts of floods, provide security for flood monitoring equipment, and disseminate information in the local language(UNISDR, 2015).

Savings and Credit schemes

Savings and credit schemes have been increasingly seen as tools for not just economic development but also climate resilience. In Busia County, savings and credit schemes are mostly done collectively through forming financial help groups and SACCOs. Linkages formed between community groups, NGOs and CBOs has enhanced the capacity to control floods through collaborative action. Some financial groups have also incorporated micro-insurance into their activities which help households to pull resources and access insurance Mehring et al. (2018).

While savings and credit schemes play an important role, many households operate with limited funds hence making their operations small scale. Secondly, majority of households fail to participate due to low incomes and increased poverty levels due to consecutive flood events. Lastly, households also lack financial literacy on how to manage their resources in the face of flood disasters and need to cater for basic needs (Fagariba et al., 2018).

Water Harvesting

In Busia County, water harvesting plays a crucial role in flood control given the region's vulnerability to floods through reducing surface runoff. Many households, particularly in rural areas have faced the dual challenge of dealing with excess water during the rainy season and water

shortages during dry spells. Rooftop harvesting strategy which involves installing gutters and downpipes to collect rainwater from roofs to storage tanks is the most common technique used. In some areas, communal rainwater harvesting systems have been used so as to provide water for larger groups (D'Souza et al., 2021).

Unfortunately, households are facing numerous challenges: First, due to lack of adequate awareness on the benefits of water harvesting in flood control, households tend to use it at small scale levels. This indicates that households are not exploiting their full potential hence they fail to derive the maximum benefits of this measure. Secondly, reliance on natural water sources such as lakes and streams additionally undermines the importance of water harvesting making households vulnerable during periods of high water flow. Thirdly, the initial cost of setting up rainwater harvesting systems can be prohibitive for low income households. Regular maintenance of these systems require households to have technical knowledge and financial resources Wenger (2015).

Bardhan (2022) reported that non-structural measures are in better agreement with the spirit of sustainable development in that the objectives of these measures are economically attainable, socially acceptable, and environmentally sound. Canada, for example, developed flood-related policies throughout the 1980s and 1990s to reduce casualties. This encouraged the construction of multi-purpose facilities such as parks rather than residential buildings near a floodplain and tightened regulations on construction. Additionally, activities such as flood zoning, a flood insurance program, and a flood forecasting and early warning system were introduced. Dhaka also confirmed the importance of the non-structural measures after implementing them following a great flood in 1988 where only the structural measures were in use(Kang et al., 2009).

While non-structural flood control measures offer significant advantages, challenges persist. These include the need for effective governance, raising awareness, financial resources, and overcoming cultural and behavioral barriers (Shah et al., 2018).

2.2 Perception of flood mitigation among individuals and community groups

Understanding how the general public views flood risk is an important factor in the assessment of flood management and warning dissemination systems. Attitudes to risk are important because, in flood disasters as in other natural disasters, a fraction of the population is habitually at risk (Mashi et al., 2020). Williams et al. (2019) argued that for participatory flood risk management to be effective, it is necessary to understand how residents perceive flood risks and disaster preparedness actions. On examining the social perception of floods and flood

management in Spain, Lara et al. (2010) concluded that perception influences citizens' preference regarding alternatives to curb flood losses. Lechowska (2018); Wang et al. (2018) noted that flood risk and response perceptions are notably influenced by knowledge and experience. Accordingly, providing the public with flood risk and management information increases its perception.

Participation of individuals and community groups is considered essential in the response and recovery actions after a disaster. However, households cannot be expected to respond accordingly if they are not knowledgeable about the impending risks and the best course of action. Being aware of the strategies that can help them mitigate losses enables households to evaluate their capability to respond and recover from disasters (Cubelos et al., 2019; Tarchiani et al., 2020; Timothy et al., 2006). Various countries have put considerable effort into improving people's understanding of flood risks through raising awareness which in turn shapes their perceptions.

Hudson and Wouter Botzen (2019) acknowledged the importance of flood mitigation awareness among locals to allow for planning and preparation to respond. Furthermore, unplanned responses and recovery could lead to increased economic losses and trauma. To achieve raising awareness in the community, government officials and the private sector were involved in passing on the required information to help the community minimize casualties, damage to infrastructure, and costs of cleaning up after the floods in New Zealand. In the city of Prague Europe, a digital training tool that was developed allowed a large population to learn and take part in short surveys. The response teams were then able to gather information on how various groups of the population perceived the flood risk and their response options (Li et al., 2012).

In past flood experiences, the perception of mitigation strategies is shaped depending on what worked best at a certain time. In Nyando County, Western Kenya, communities developed a positive perception towards implemented structural measures since they felt they had survived major floods courtesy of these measures (Nyakundi et al., 2010). Experience also builds on the knowledge gained before which all leads to the perception that eventually influences people's responsive behavior.

Paul and Hossain (2013) explored peoples' perceptions of flood disaster management and mitigation measures undertaken by the government and non-government organizations in the Chalan Beel area of Bangladesh. Findings showed that the government has given more attention to structural flood management measures in the area while non-structural and long-term sustainable flood management strategies have received little attention. The warning system was

ineffective because the information disseminated to them was unclear and technical. The government rescues, relief, and rehabilitation operations were also considered insufficient for peoples' needs. More than half of the population felt that flood management activities undertaken by the government were not effective because of improper implementation, corruption, and inefficiency. The study concluded that it was important to develop peoples' awareness of suitable coping strategies that may be employed to enhance the long-term resilience of people.

2.3 Extent of Flood Mitigation in Kenya

In Kenya, heavy rainfall is the main cause of floods affecting people living in rural and urban areas. These floods occur in the form of urban, riverine, or coastal floods. The most affected areas in the country are Nyanza, the western region, and Tana River County (Odidi et al., 2020). In urban areas like Nairobi city, people dwelling in informal settlements are the hardest hit by flash floods which are intensified by rapid urbanization and poor urban planning (Baariu, 2017; Mulligan & Kipkemboi, 2017).

The main riverine floods occur in the Nyanza region, river Nyando being responsible for floods with Kano plains being the most affected. In Western Kenya, river Nzoia is the main culprit with Budalangi being the most affected area. The arid, semi-arid areas like Garissa and Wajir are also susceptible to flash floods. Coastal areas like Kilifi and Kwale are affected by coastal floods (Otuya & Ochieng, 2018).

In the pursuit of reducing vulnerabilities to risks, the government of Kenya formulated a National Policy on Disaster Management to institutionalize mechanisms for addressing disasters. The policy emphasized preparedness on the part of stakeholders in Disaster Risk Reduction activities. In this regard, the policy aimed to strengthen disaster management institutions and partnerships and mainstream disaster risk reduction in the development process to strengthen the resilience of vulnerable groups in coping with disasters. The formulation of this policy has been a collaborative effort of relevant ministries, international partners, non-governmental institutions, districts, and other lower administrative levels with the Ministry of Special Programmes being at the forefront in coordinating Disaster Risk Reduction initiatives (Rotich & Box, 2019).

Vulnerable low-income households have for a long time relied on short-term, unsustainable strategies to cope with the floods (Nyberg et al., 2020). Short-term strategies such as selling labor, eating fewer meals, queuing for food aid, withdrawing children from school to help with household chores, and reducing expenditure for necessities are in use (Nguimalet, 2018). These measures are

however considered negative but necessary for survival. They leave households vulnerable and are not sustainable solutions for household resilience (Masese et al., 2016).

Communities have however evolved ways of co-existing with their natural resources and even with disasters (Dulo et al., 2010; Ongor, 2007). Notable efforts by the government such as the Ministry of Water and Irrigation taking part in implementing structural flood control measures aimed at taming floods have been seen even though these measures have had failures (Blomstrand et al., 2006). In Tana River, for example, there have been efforts by the county government to bring about integrated development through watershed management. The government of Kenya initiated the development of Tana River water resources for hydropower development, flood control, and irrigation. Five major reservoirs have been built in the upper reaches of the river and they have helped in regulating water flow and decreasing the frequency and magnitude of flooding. Further, the Kenya Red Cross agency initiated a two-year flood recovery project which focused on community health and overall training in critical hygiene techniques (Mulwa, 2013).

Western Kenya has had some government projects initiated in reaction to flood incidences. In 2004, the Water Resource Management Authority (WRMA) formulated an integrated flood management policy focusing on Lake Victoria Basin. It was intended to raise awareness of the community and strengthen institutional capacity to allow flood mitigation, prediction, and warning through protecting, developing, and managing water resources to prevent the hampering of the development process and sustainability of water resources (WMO/APFM, 2004).

The Western Kenya Community Driven Development and Flood Mitigation (WKCDD/FM) Project was developed to address the causal factors that produce recurrent floods and simultaneously help communities identify livelihoods that can be productively pursued in a more stable natural environment. This project was informed by the report “Strategy for Flood Management for Lake Victoria Basin”, jointly prepared by WMO/APFM Kenya Ministry of Water & Irrigation and Kenya Meteorological Department (KMD). The Report recommended the Integrated Flood Management Approach comprising of structural measures; dykes, river training, check dams-control of siltation, multi-purpose dams hydropower, irrigation, fishing, non-structural measures; Catchment management (reforestation, agricultural practices, conservation of riparian areas), community awareness and education, early warning system, clearing of the channel (vegetation, sediment deposits), dyke management, poverty reduction, Participatory approach: community, inter-sectorial, inter-ministerial, CBOs and religious organizations (Njogu, 2017).

This project saw the development of a flood forecasting and early warning system. Water radar sensors were installed to warn downstream dwellers of possible floods. Further, Bulala Radio station was started in western Kenya to disseminate flood forecasts to rural communities in flood-prone areas (Weingärtner et al., 2019).

Japan International Cooperation Agency (JICA) carried out the ‘Programme for Community-based Flood Disaster Management to Adapt to Climate Change in Nyando River Basin (2009-2011)’ aiming to establish a flood management system in the southern part of Lake Victoria Basin through IFM based on the achievement of the Nyando project. This was meant to strengthen community participation in activities involving flood management (JICA, 2014).

There have, therefore, been notable efforts to manage floods in Kenya, however, communities are still grappling with the negative effects of floods due to the constraints on their livelihoods and dependence on projects and government relief.

Structural measures are more dominant and remain an important element in flood mitigation, however, non-structural measures are more efficient and sustainable. KMD, WRMA, County governments, and relevant ministries have non-governmental organizations that have been involved in promoting the use of non-structural measures such as early warning systems, land use regulations in both rural and urban areas, and water management practices in various counties. The engagement of the communities has however been slow due to various challenges such as reliance on indigenous knowledge, lack of awareness on what works best in various areas by communities and authorities, cultural hindrances, and shortness in periods of project implementation due to low funding (World Bank, 2019).

2.4. Factors influencing the adoption and use of flood control measures among households

Floods pose significant risks to communities worldwide, and households play a critical role in mitigating these risks. To support the planning and implementation of climate-resilient measures for sustainable development, understanding the factors that influence mitigation and adaptation actions is crucial. Due to massive losses experienced, households have become motivated to apply risk reduction measures complementary to public measures and develop their own level of resilience that adapts their livelihood strategies to the flood pattern. Several studies have examined the factors that influence households to take flood mitigation measures. (González-Hernández et al., 2019) found that socio-demographic factors, perceived flood knowledge and financial self-efficacy more prominent in influencing climate change action among households in Mexico. Age,

flood experience, trust in government, monthly income and insurance willingness were found more influential in Shenzhen, China (Cao et al., 2020). This literature review explores a range of factors, including socioeconomic, environmental, cultural, and individual characteristics which shape households' decisions to adopt or neglect flood mitigation measures.

Socioeconomic Factors

Income and Financial Constraints: Research consistently highlights the influence of income on households' ability to adopt flood mitigation measures. High upfront costs for protective infrastructure, such as levees or barriers, can create financial barriers for lower-income households. Studies suggest that financial assistance, subsidies, or innovative financing mechanisms can alleviate these constraints and promote adoption (Ahmad & Afzal, 2020).

Education and Awareness: Educational attainment within households is closely linked to awareness and understanding of flood risks and mitigation measures. Higher education levels are associated with increased knowledge about the benefits of adopting protective measure (Bubeck et al., 2012). Effective communication and educational campaigns can bridge knowledge gaps and empower households to make informed decisions regarding mitigation.

Insurance Coverage: The role of insurance in influencing flood mitigation adoption is a dynamic area of research. While insurance can provide a financial safety net, its effectiveness in promoting mitigation measures depends on factors such as policy coverage, affordability, and households' risk perception. Literature suggested that enhancing insurance literacy and incentivizing mitigation through premium adjustments can encourage adoption (Nikkanen et al., 2021).

Environmental Factors

Geographic Location and Topography: The geographic location and topography of households significantly influence their exposure to flood risks. Proximity to rivers, coastlines, or low-lying areas increases vulnerability. Diakakis et al. (2018) emphasized the need for tailored mitigation measures based on local geography, considering factors such as elevation, soil type, and proximity to water bodies.

Climate Change Awareness: As climate change intensifies the frequency and severity of floods, households' awareness of these changes becomes crucial. Masud et al. (2017) suggested that households with a higher awareness of climate change are more likely to adopt adaptive

measures. Educational campaigns emphasizing the link between climate change and increased flood risks can enhance awareness and stimulate proactive mitigation.

Cultural and Social Factors

Social Networks and Community Influence: The social context within which households are embedded plays a pivotal role in the adoption of flood mitigation measures. Strong social networks and community cohesion can positively influence behavior by fostering collective action. Mondal et al. (2021) emphasized the importance of community-based approaches that leverage social capital to encourage households to collectively invest in mitigation.

Cultural Beliefs and Perceptions: Cultural factors shape households' perceptions of risk and influence their willingness to adopt mitigation measures. Grigorieva and Livenets (2022) indicated that cultural beliefs regarding the inevitability of floods or the efficacy of traditional coping mechanisms may hinder the adoption of modern mitigation strategies. Tailoring interventions to align with cultural values can enhance acceptance and effectiveness.

Individual Characteristics

Risk Perception and Experience: Households' perception of flood risk is a key determinant of mitigation adoption. Those who have experienced previous flooding are more likely to adopt protective measures. Understanding the psychological aspects of risk perception, including the availability heuristic and optimistic bias, can inform communication strategies that address cognitive biases and promote preparedness (Demski et al., 2017).

Motivation and Behavioral Change: Brouwer and Schaafsma (2013) underscored the importance of understanding individual motivations and barriers to behavioral change. Behavioral economics concepts, such as loss aversion and temporal discounting, provide insights into decision-making processes. Interventions that leverage positive motivations, framing messages effectively, and minimizing cognitive biases can enhance the adoption of flood mitigation measures.

2.5 The impact of flood risk mitigation strategies

The impact of flood risk mitigation measures is multifaceted and extends across various sectors, including the environment, economy, public health, and social well-being. Flood risk mitigation aims to reduce or prevent the adverse effects of flood events through interventions and strategies. Here's an overview of the impacts of flood risk mitigation measures:

Environmental Impact

Preservation of Biodiversity and Natural Habitats: Flood mitigation efforts often involve habitat preservation, afforestation, and sustainable land use practices (Frank & Havl, 2017). These measures help conserve biodiversity, protect ecosystems, and enhance resilience to climate change. Preserving natural habitats also contributes to carbon sequestration, further mitigating the impacts of flood disasters (Feliciano et al., 2022).

Economic Impact

Adaptation and Resilience Investments: Flood risk mitigation measures include investments in adaptation strategies and resilience-building efforts. While these investments incur costs, they can result in long-term economic benefits by reducing the damages caused by flood disasters. Enhanced resilience can protect infrastructure, agriculture, and other economic sectors from the impacts of extreme weather events (Yang et al., 2021).

Community stability: Effective flood mitigation measures contribute to community stability by safeguarding homes, businesses, and critical infrastructure. This, in turn, supports economic activities and local economies (Bosello et al., 2018).

Public Health Impact

Vector-Borne Disease Reduction: Climate change can influence the spread of vector-borne diseases. Mitigation measures that address climate-related factors, such as changes in temperature and precipitation patterns, can contribute to the reduction of diseases transmitted by vectors like mosquitoes and ticks (Vinet, 2017).

Social Impact

Equity and Social Justice: Flood mitigation efforts need to consider issues of equity and social justice. Certain communities may be disproportionately affected by climate change, and mitigation measures should aim to minimize these disparities. Additionally, community engagement in the development and implementation of mitigation strategies is crucial for their success (Bubeck et al., 2017).

Community Resilience: Implementing flood risk mitigation measures often involves community-level initiatives. These can enhance community resilience by fostering preparedness, providing early warning systems, and promoting sustainable practices that protect vulnerable populations (Houston et al., 2021).

Action starts with mobilization from the community or disaster management bases to strengthen organizational bases for local flood mitigation initiatives. In the past, activities were based on individual initiatives, however, people learned to get involved in community actions to strengthen their resilience (Dulo et al., 2010). Communities now focus on awareness raising, capacity building at individual and community levels, planning, and implementation. Depending on household capacity, real-time responses can determine household welfare then and in the future.

Using the Auto-Regressive Integrated Moving-Average time series methodology, Son et al. (2015) determined the effects of mitigation measures on flood damage prevention in Korea. Results showed that non-structural measures used (prior evacuation plans) were seen to influence flood damage mitigation immediately after they were introduced and continued to be effective after the policy intervention compared to structural measures whose effects emerged slowly.

Using propensity score matching (PSM), Li (2012) evaluated the performance of a Community Rating System (CRS) of the National Flood Insurance Program on average property damage during flooding events across counties in North Carolina. The results revealed that property damage was reduced in the range of approximately \$14,000 and \$23,000 per county, hence concluding that the non-structural measure was effective.

Dartanto (2019) examined the relationship between natural disasters, mitigation, and household welfare using three econometric models in Indonesia. The first model, an OLS regression looked at the relationship between household natural disaster experience and household per capita consumption. The results revealed that household welfare was reduced. The second and third models were ordered Logit models that were estimated using maximum likelihoods. The second model estimated whether the natural disaster experience influences household poverty status. Results showed that households were not necessarily impoverished because mitigation strategies such as reconstruction of damaged roads and bridges prevented such adverse effects. Findings also showed that households that have disaster preparation practices in place tend to be non-poor. The third model examined the impact of natural disasters on changing household poverty status from non-poor to poor. Findings revealed that non-poor households became poor after natural disasters struck and the probability of remaining poor for a longer time increased by 0.5%.

The impacts of climate risk mitigation strategies on livestock production on household welfare were determined using propensity score matching (PSM) (Rahut & Ali, 2018). The

average treatment effect (ATT) indicated the difference in outcomes for farmers who adopted climate change mitigating strategies and for those who did not. The PSM results show that climate risk coping strategies have a positive impact on household welfare as the adopters have higher yields and income compared to non- adopters.

2.6 The concept of household welfare

Welfare measures allow for the estimation of patterns in standards of living across populations over time. Consumption expenditure, asset accumulation, and income are commonly used as proxies for household welfare. Income and consumption have been debated intensely by researchers with a clear consensus on favoring consumption over income (Moratti & Natali, 2012). First, consumption seems to be better in capturing the concept of standard of living since individuals derive material well-being from the actual consumption of goods and services rather than from income. Consumption better reflects long-term income as it is not closely tied to short-term fluctuations, it smoothens over seasons and is less variable than income (Deaton & Zaidi, 2002).

Income is more likely to be affected by seasonal patterns resulting in either an underestimation or overestimation of real income. Although collecting data on consumption is usually very time-consuming, the concept of consumption is usually clearer than the concept of income. Furthermore, it is extremely difficult to accurately measure household income, especially for self-employed households and those working in informal sectors. Finally, income is likely to be a more sensitive issue for respondents than consumption. Those who are well-off are less likely to participate in the survey or respond leading to an underestimation of income inequality among the population (Brewer & O’Dea, 2012).

Assets indices are also an alternative measure of welfare. In recent years, the use of asset-based wealth indices as an alternative metric has become increasingly prominent. Although this index is suitable for analyzing multidimensional poverty and is less data-intensive hence easier to calculate, different studies report that the asset index is a poor proxy for current household income or expenditure even though it may reflect permanent income (Filmer & Pritchett, 1999). Some reasons limiting the use of asset bases indices are; first, this index measures household wealth relative to other households in the sample but does not quantify the households’ current levels of welfare or poverty. Secondly, it has been found to have an urban bias and limited discriminatory power at the lower end of the wealth distribution. Thirdly, differences in price levels as well as

asset quality across regions are not taken into account in the asset-based approach (Filmer & Pritchett, 1999). Wealth index therefore cannot be used as a perfect substitute for income or consumption which among other considerations remain the most common and accepted measures of welfare. For the reasons mentioned above, this study used consumption expenditure as a measure of household welfare.

2.7 Theoretical framework

A combination of theories is better in practice when explaining human behavior towards risk, especially in the natural environment (Palm & Hodgson, 1993). This study considers these theories to explain household preparedness and actions upon receiving warning information on impending risks.

The cognitive theory emphasizes the role of thinking, imagination, emotions, and values in human action. Human behavior is formed by how the person processes information perceived from the environment. According to this theory, people who receive risk information go through a sequential process that shapes their perception and behavior. Perception in this case refers to what people understand and believe while response is what people decide about alternatives in preparing and mitigating actions. This theory presumes that preparedness and mitigation behavior is a consequence of perceived risk (Mileti & O'Brien, 1992).

The need theory stresses the importance that the individual places on the meaning of events and experiences. According to Maslow's theory of human behavior based on humanistic need principles, security, and safety needs are important but not more than physiological needs. The hierarchical system of needs varies between households and communities. Unless basic needs are fulfilled, safety needs such as those against natural disasters may be considered unimportant hence unobserved mitigation behavior (Asgary & Willis, 1997).

Another theory is the cultural theory. Culture is seen as a powerful influence as it organizes a societal social structure which in turn governs people's behavior. Renn (1992) has demonstrated that responses to risks are a function of cultural belief systems. A study by Palm and Hodgson (1993) reveals that some cultures may consider natural disasters as acts of God, inevitable and beyond human control even to mitigate the consequence; hence very limited mitigation behavior and acceptance of recommendations of mitigation measures. On the other extreme, other cultures adopt a positive outlook believing that technology and government action can mitigate their worst impact.

Lastly, the economic theory argues that human response to environmental risks is influenced by economic resources, hence, safety is a function of income and wealth (Asgary & Willis, 1997). Poorer people are more vulnerable to environmental risks because they live in houses with fewer safety measures or locations prone to various disasters (Mulwanda, 1992). Low income therefore prevents voluntary mitigation actions against risk. The attributes in these theories intertwine to determine the preparedness and mitigation decisions made by households. A household for example may be aware of the impending disaster and the mitigation measures recommended but is constrained financially or by cultural beliefs and so on as scenarios are different for individual households.

2.8 Conceptual framework

The impacts of non-structural flood control measures can be influenced by age, occupation of households, household size, education, marital status, monthly income, access to climate information, and previous experience through household response. It is assumed that households will respond to the non-structural flood control measures available through how they perceive these measures. Their perception will influence the extent to which they believe and act on the early warning information, water harvesting, savings and credit schemes as well as land regulations. This will improve their resilience which will lower their vulnerability to floods. Low vulnerability means that they are less exposed to risk. Households therefore experience less property and financial losses. This gives them the ability to get back to their income-generating activities once the risk is over and their welfare is sustained. The interdependence of these variables is shown in Figure 1.

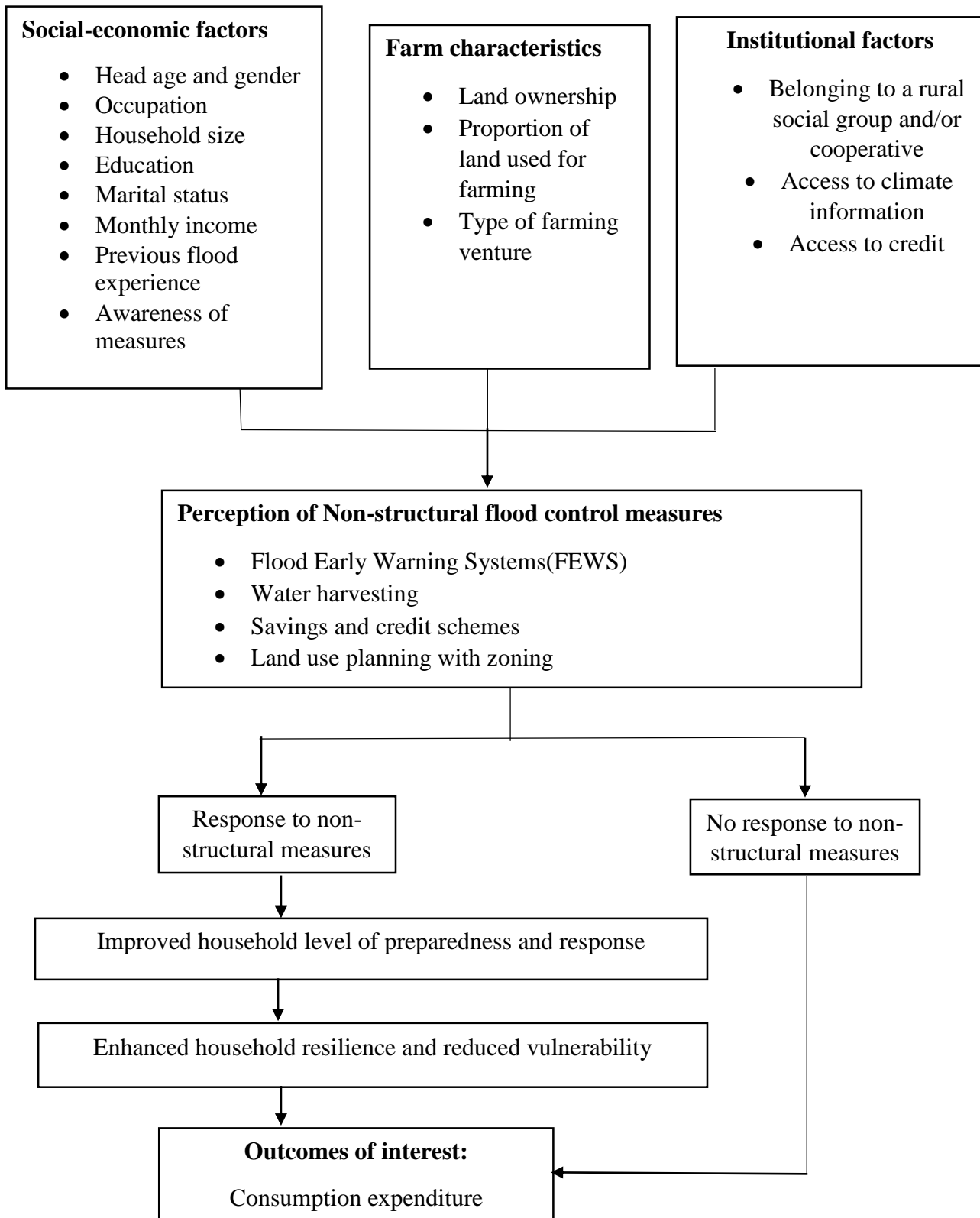


Figure 1: Conceptual Framework.

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

Bunyala sub-county is one of the seven sub-counties located in Busia County in western Kenya. The sub-county borders Samia to the north, Siaya to the east, Bondo to the south, and Lake Victoria to the west. It has 6 administrative locations and 18 sub-locations. According to KNBS (2019), the population of Bunyala sub-county stands at 85,977 people with an average of 19039 households and the average household size is 4.5. This sub-county records the lowest number of people in all the seven sub-counties. This is attributed to the fact that the area is a wetland. The sub-county covers an area of 192.2 square kilometers with a population density of 447 people per square kilometer.

The area experiences an average rainfall of about 750mm and 1015mm and has alluvial soils that support small-scale agriculture of both crops and livestock. Other activities include fishing and non-farm activities such as petty trade. The long rains are at a peak between March and May while the short rains fall between August and October. The dry season with scattered rains falls between December and February (MoALF, 2018).

Subsistence farming is the main economic activity for households in the area with farms averaging 2 acres. The main food crops grown in this area include maize, sorghum, and beans. Rice is the major cash crop in the area majorly done in Bunyala Irrigation Scheme. Livestock farming mainly involves the rearing of free-range indigenous chicken at a small scale ranging between 5 to 20 birds per household. This is because of the small space requirement required for this venture. Farmer groups and handymen assist in the construction of housing units. The area covers both fish farming and capture farming. Most of the fish is however exported to major markets like Nairobi and Mombasa (Andika et al., 2011; MoALF, 2018). Non-farming activities include sand harvesting, fishing and trading. The road network mainly comprises gravel surface and earth surface roads some of which are impassable during the rainy season due to poor drainage. Markets in the rural areas are mainly open-air with agricultural produce being the main sale. Kenya Commercial Bank (KCB) is the financial institution in the sub-county (Busia County, 2018).

River Nzoia drains into Lake Victoria through the Bunyala plains. Bunyala is a low-lying area with a generally flat landscape that predisposes the area to recurrent floods that occur every two years on average. This can be attributed to the overflowing of River Nzoia due to the bursting of the river banks. This situation is aggravated by the backflow of Lake Victoria due to siltation in River Nzoia causing inundation for long period. Floods affect all the locations in the sub-county, however, those closest to river Nzoia and Lake Victoria are the hardest hit (Busia County, 2018). The FEWS is used across Bunyala as the intention for the development of this system was focused on the entire western region affected by floods. Projects for setting up Water harvesting systems and insurance have focused on flood mitigation for the most affected areas. Land use planning with zoning policies was meant to protect land around water resources. The sample used was therefore of households living near River Nzoia and Lake Victoria. These households had the choice to participate or not in participating and taking up these non-structural measures. The study area is shown in Figure 2.

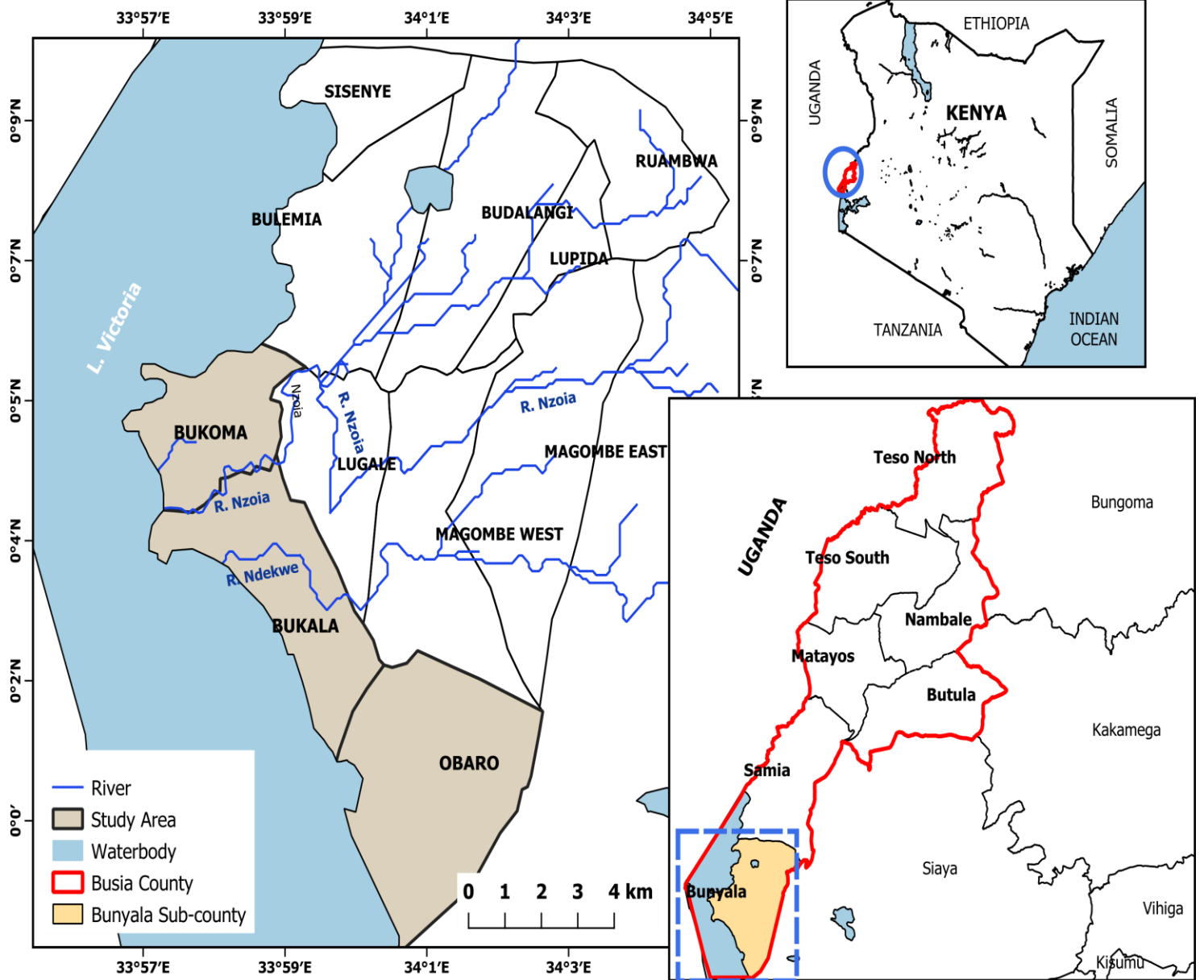


Figure 2: Map of Bunyala Sub-County

Source: Ayeb-Karlsson et al. (2019)

3.2 Sample size determination

The population from which the sample was drawn consists of households in Bunyala sub-county. The sample size was determined using Cochran's (1963) formula for infinite population (≥ 50000) as follows;

$$n = \frac{pqZ^2}{e^2}$$

$$n = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2} = 384$$

Where; n- sample size

p- Sample proportion (use 0.5 if p is not known)

q- 1-p

d- Confidence coefficient (precision)

Z- Standard deviate at a 95% significance level

3.3 Sampling procedure

This study used a multistage sampling procedure. Busia County was purposively selected as it is one of the most flood-prone areas in the country located in the lower reaches of River Nzoia. Bunyala Sub-County was purposively selected as it is the Sub-County that experiences more flood

events compared to the rest. Bukoma, Rukala, and Obaro sub-locations were purposively selected due to their proximity to Lake Victoria. Sub-County staff, assistant chiefs, and village elders were consulted to help in generating the list of households that have been in the area for at least five years as they have experienced at least two flood events. Respondents were drawn from the sub-location using a simple random procedure. The sample size was divided in proportion to the size of the household population of the three sub-locations. According to the 2019 census, the estimated household population for Bukoma, Rukala, and Obaro was 1558, 896, and 576 respectively.

Table 1: Sample Size Distribution

| Sub-locations | Population | Sample Proportion | Size | Participants proportion | Non-participants proportion |
|---------------|-------------|-------------------|------|-------------------------|-----------------------------|
| Bukoma | 1558 | 197 | | 131 | 66 |
| Rukala | 896 | 114 | | 76 | 38 |
| Obaro | 576 | 73 | | 49 | 24 |
| Total | 3030 | 384 | | 256 | 128 |

3.4 Data collection method and analysis

The study employed primary data collected through semi-structured questions which were administered by trained enumerators. Both observation and face-to-face interviews were used. The data was analyzed using STATA computer statistical software and Statistical Package for Social Sciences (SPSS).

3.5 Model specification and analysis

3.5.1 Objective One: Perception of non-structural flood control measures among households.

Descriptive statistics were used to form simple summaries about the perception of households through a Likert scale towards non-structural measures. Tables were used to present the results.

3.5.2 Objective Two: The extent and factors influencing the extent of using non-structural flood control measures by households.

This objective used the Multivariate Multiple Regression model which is used to model multiple dependent variables with a single set of predictor variables. The multinomial model would also have been a good choice for this objective since non-structural measures could be considered nominal in nature, however, this model is used to predict the probabilities of different possible outcomes of the nominal variable and this did not match my objectives (Bel & Paap, 2014). The dependent variables were extent for FEWS, land planning with zoning, savings and credit schemes, and water harvesting. Independent variables were land ownership, EW duration, flood effect, EW awareness, land regulation awareness, access to credit, access to climate information, and consecutiveness of floods. The intuition behind the choice of these variables is based on the diffusion theory and the protection motivation theory. According to the diffusion theory, taking up a strategy, idea, technology or product occurs in 5 stages: awareness, interest, evaluation, trial, and adoption. This theory identifies various factors influencing the rate of taking up a practice which include; the characteristics of the practice, characteristics of those taking up the practice, communication channels through which the information about the practices is transmitted, and the social content within which the practices are being used (Dearing & Cox, 2018).

The protection motivation theory explains flood preparedness decisions. This is explained using a variety of other variables that can have an important influence on individual decision-making under risk such as risk attitudes, time preferences, social norms, and local flood risk management policies.

The multivariate multiple regression model is as such:-

$$Y_{im} = \beta_{om} + \beta_{1m}Z_{i1} + \beta_{2m}Z_{i2} \dots \dots \dots \beta_{rm}Z_{ir} + \varepsilon_{im} \dots \dots \dots 1$$

Whereby: - m are the dependent variables

r are the predictor variables

i are the number of observations

In general, the model can be represented as:-

$$Y_{(j)} = Z\beta_{(j)} + \varepsilon_{(j)} \quad j = 1,2 \dots \dots m \dots \dots \dots 2$$

$Y(j) \sim$ values of the jth response variable for each of the observation

of predicted responses generated upon a known matrix of predictor variables Z and the estimated parameter matrix β' . This is generated by the matrix equation:-

$$Y' = Z\beta'$$

Once the Y' matrix is computed, the predicted error matrix ε' can be obtained by $Y - Y'$ giving the distances between the observed and predicted Y_{ij} values. β' is an unbiased estimator and the maximum likelihood estimator for β . β' and ε' are uncorrelated.

Using the predicted error matrix ε' we constructed a new corresponding matrix case:-

$$E(\varepsilon_{(j)} \varepsilon_{(k)}) = \sigma_{jk}(n - r - 1) = \Sigma(n - r - 1) \dots \dots \dots 4$$

To find the MLE, we worked with the single response model first and extended the resulting estimator to the multivariate case. Considering the natural log we have the:-

$$\ln L(\beta_{(j)}, \sigma_{jj}^2) = -\frac{n}{2} \ln 2\pi - n \ln \sigma_{jj} - \frac{1}{2\sigma_{jj}} (Y_{(j)} - Z\beta_{(j)})' (Y_{(j)} - Z\beta_{(j)}) \dots \dots \dots 5$$

Taking the derivative we differentiate for σ_{jj} and $\beta_{(j)}$ to obtain:-

$$\frac{n}{\sigma_{jj}'} + \frac{1}{\sigma_{jj}^3} (Y_{(j)} - Z\beta_{(j)})' (Y_{(j)} - Z\beta_{(j)})'$$

Setting the derivative at 0 and solving for σ_{jj} will give us the value at which the log-likelihood function is maximized as follows:-

$$\sigma_{jj}^2 = \frac{1}{n} (Y_{(j)} - Z\beta_{(j)})' (Y_{(j)} - Z\beta_{(j)}) \dots \dots \dots 6$$

$$\sigma_{jj}^2 = \Sigma'$$

Table 2: Variables description in the multivariate regression

| Variable | Description and measure | Expected sign |
|------------------------------|---|----------------------|
| Dependent variables | | |
| HHpart. Extent | Household participation extent for: Savings and credit schemes, FEWS, land regulations, and water harvesting 1=rarely(NE) 2=sometimes(LE) 3=often(ME) 4=always(HE) | |
| Independent variables | | |
| Hhldowp | Household land ownership 1=yes 0=no | +/- |
| EWduration | Duration of receiving EW before flood event <80 days >80 days | +/- |
| Floodeff | Flood effect 1=extremely 2=moderately 3=never 4=slightly | + |
| EWawa | EW awareness 1=no 0=yes | + |
| LDawnss | Land use planning awareness 1=no 0=yes | + |
| Crdtacs | Access to credit 1=yes 0=no | + |
| Clmtinf | Access to climate information 1=yes 0=no | + |
| Consfloods | Consecutiveness of floods 1=yes 0=no | +/- |

3.5.3 Objective Three: Impact of non-structural flood control measures on household welfare.

Propensity Score Matching (PSM) was used to determine the impact of non-structural flood control measures on household welfare. The households that participated in non-structural flood control measures were used as the treated group while those that did not participate in the non-structural flood control measures as the control group. The purpose was to compare the consumption expenditure for those who took up these measures and those who did not.

Upon collecting data, selection bias was anticipated. However, to eliminate the selection bias, PSM uses the probability of employing the treatment, propensity score (PS) to match individuals in the treatment and control group. Propensity Scores remove dimensionality issues and compress relevant information into a single value hence making it easy to match individuals. In the estimation of the predicted values of the probability of participation, a probit model was used as shown:

$$P(X_i) = \Pr(D = 1|X_i) \dots\dots\dots 1$$

Where $P(X_i)$ is the probability of participation in non-structural control measures, $D=1$ for participants and $D=0$ for non-participants. The regression function is as shown:

$$P_i = \varphi(\theta_0 + \theta'X_i + \varepsilon_i) \dots\dots\dots 2$$

Where: φ is the standard normal distribution, θ' is the vector of coefficients, X_i is the vector of explanatory variables; containing confounding variables that are both related to participation and outcome and ε_i is the error term that is assumed to be normally distributed.

According to Brookhart et al. (2006), one should include variables that are thought to be related to the outcome regardless of whether they are related to the exposure. This is because even if a covariate is theoretically unassociated with participation, there can be some slight chance of relation for any given realization of a data set. Including such a covariate in a PS model corrects for small amounts of chance bias hence improving the precision of the estimator.

Baseline confounders include age, gender, education level, household size, and various household characteristics. The intuition behind the inclusion of outcome variables in this study is based on the elements of the Crichton risk triangle; which capture hazard, vulnerability, and exposure as the three risk components (Wolf, 2011).

Once the model was estimated, the balancing assumptions were tested using t-tests. The sample was stratified by PS and tested for lack of difference between the control and treatment of each stratum. After balancing, the matching process was done.

There are different matching techniques. First, the nearest-neighbor matching which involves matching the person with the closest PS in the control group. This type of matching can be done with or without replacement. Matching with replacement is whereby a person in the control can match more than one treated while without replacement is when once a control has been matched, it cannot be used to match another treated.

Second, the caliper or radius matching involves matching individuals in the control and treatment group that lie within a band width around the interested PS. Bad matches are reduced due to the bandwidth, however, if no agent is located inside the radius, then there is no match for them. Third, the stratification matching where the area around the PS overlap is partitioned into strata. Each stratum is defined over a specific range of the PS and within each stratum, there are no statistically significant differences between the treatments and control groups.

Lastly, the Kernel technique where the weighted average of all observations in the control group is used to create matches for the members of the treatment group. The greater the distance between the PSs, the lower the weight. In this model, all members of the control group are used to create a counterfactual for the treatment hence bad matches will be included. The weighting process however reduces the influence of bad matches. Bandwidth is very important here as it determines the degree of smoothing, however, it is unclear what the correct bandwidth is hence its selection is treated as a tradeoff between bias and variance.

The nearest-neighbor method was used to match the control and the treatment group. Each treatment was matched to the suitable control with the closest PS. However, it may be that the nearest neighbor is very far in terms of the PS. Matching with replacement was used to address this issue hence ensuring reduction of bias. After matching, the Average Treatment Effect (ATE) was estimated. The average outcome of the treated was compared to the average outcome of the control group. The difference between the outcomes is the impact of non-structural measures on households as shown:

$$\delta_i = y_{1i} - y_{0i} \text{ Hence}$$

$$ATE = E(\delta_i) = E(y_1 - y_0) \dots \dots \dots 3$$

Where y_1 is the outcome of the participants and y_0 is the outcome of non- participants.

Table 3: Covariates for propensity score matching

| Variable | Description and Measure | Expected sign |
|------------------------------|--|----------------------|
| Dependent variables | | |
| HHconexp | Household consumption expenditure Ksh | + |
| Independent variables | | |
| Hhage | Age of household head age Years | +/- |
| Hhgender | Gender of the household head 1=male 0=female | +/- |
| Hhsize | Household size Number | + |
| Hhldowp | Household land ownership 1=yes 0=no | + |
| Hhmincome | Household monthly income Ksh | + |
| Hheduc | Education level of the household head 1=primary2=secondary3=tertiary 0=none | + |
| Hhoccp | Household head occupation 1=farmer2=government sector3=private sector4=self-employed5=unemployed6=other(specify) | +/- |
| Marstat | Marital status 1=divorced 2=married 3=single 4=widowed | +/- |
| Crdtacs | Access to credit 1=access 0=no access | + |

| | | |
|------------------|---|-----|
| Sclgrp | Belonging to a social group 1=yes 0=no | + |
| Clmtinf | Access to climate information 1=access 0=no access | + |
| EWdur | length of time of receiving information before the flood event-Days | +/- |
| Frsk | Flood risk(if households have suffered three consecutive flood events) 1=yes 0=no | - |
| Savings | Households savings 1=no 0=yes | + |
| Floodfreq | Flood frequency 1=always 2=never 3=often 4=sometimes | +/- |
| Floodeff | Flood effect on household 1=extremely 2=moderately 3=never 4=slightly | +/- |

CHAPTER FOUR

RESULTS AND DISCUSSION

This section presents the findings of the study. It is divided into five sections. Section one entails a summary of the socio-economic characteristics of participants and non-participants. Section two discusses the awareness of Flood Early Warning Systems (FEWS) and Land regulation practices. Section three discusses the nature of water harvesting and savings. Section four presents the results of the extent of participation in non-structural measures. Finally, section five presents the results of the impact of participation in non-structural measures on household consumption expenditure.

4.1 Socio-economic characteristics of participants and non-participants of non-structural flood control measures

Table 4 summarizes the socio-economic characteristics describing the households as related to flood control in Bunyala sub-county

Table 4: Socio-economic variables analysis of participants and non-participants in flood control measures in Bunyala sub-county

Results in Table 4 indicate that 15% of the household heads were female and 68% of them were participants in flood control measures. Male-headed households comprised 85% and 66% among participants. The results indicate that both men and women equally took up non-structural flood control measures considering the magnitude of flooding in the sub-county. On aggregate, about 78% of the households were married comprising 68% of participants and 32% non-participants. Okayo et al. (2015) note that the married take up precautionary flood control measures more compared to the single. They inferred that such households mean more members (either their own or relatives), more property, and hence higher responsibility. Also, they are considered better placed both financially and psychologically hence better mental and emotional state to respond to flood risks (Nyakundi et al., 2010).

The mean age of the household heads was 38 years and this is the time of active productive stage in life. Youths, described as individuals who are between 18 and 34 years of age participated less in non-structural measures. Muye and Steeves (2008) found that youth participation in disaster management in Busia County was low (30%). This was because family resources are in the hands of parents and the youth can only play a supportive role in the implementation of some of the flood control measures.

| Socio-economic variables | Non-participants | | Participants | | Aggregate percent |
|---------------------------------|-------------------------|---------|---------------------|---------|--------------------------|
| | Frequency | Percent | Frequency | Percent | |
| Gender | | | | | |
| Female | 18 | 31.58 | 39 | 68.42 | 14.84 |
| Male | 110 | 33.64 | 217 | 66.36 | 85.16 |
| Marital Status | | | | | |
| Single | 33 | 39.29 | 51 | 60.71 | 21.28 |
| Married | 95 | 31.67 | 205 | 68.33 | 78.13 |
| Age | | | | | |
| <35 | 53 | 41.41 | 94 | 36.72 | 33.33 |
| >35 | 75 | 58.59 | 162 | 63.28 | 66.67 |
| Household size | | | | | |
| <5.8 average | 51 | 39.84 | 77 | 60.16 | 33.33 |
| >5.8 average | 59 | 23.25 | 197 | 76.95 | 66.67 |
| Education level | | | | | |
| None | 10 | 55.56 | 8 | 44.44 | 4.69 |
| Primary | 73 | 34.23 | 132 | 65.77 | 53.39 |
| Secondary | 38 | 35.61 | 73 | 64.39 | 28.91 |
| Tertiary | 7 | 14.00 | 43 | 86.00 | 13.03 |
| Income Source | | | | | |
| Crop farming | 6 | 16.22 | 31 | 83.78 | 9.64 |
| Fishing | 65 | 49.62 | 66 | 50.38 | 34.11 |
| Livestock farm | 7 | 29.17 | 17 | 70.83 | 6.25 |
| Retired | 5 | 35.71 | 9 | 64.29 | 3.65 |
| Salaries | 4 | 9.76 | 37 | 90.24 | 10.68 |
| Trading | 37 | 29.84 | 87 | 70.16 | 32.29 |
| Others | 4 | 30.77 | 9 | 69.23 | 3.39 |

The average household size was 5.8 members which was higher than the KNBS (2019) statistic of 4.5. Results indicate that for both household size categories, there were more participants at 60.16% for those <5.8 members and 76.95% for those >5.8 members as opposed to 39.4% and 23.25% for non-participants. Twerefou et al. (2019) explain that the impact of household size on the decision to participate in non-structural flood control measures may vary among household sizes depending on various contextual factors such as resource allocation, risk perception among members, household dynamics, responsibilities, priorities, social network, and community influence.

Majority of the households (53%) had basic primary and 29% secondary education. According to Huho (2015), the education level in Bunyala sub-county was generally low due to high rates of school dropouts. This was attributed to high poverty levels escalated by flood hazards. Okayo et al. (2015) indicate that education is a major driver of participation in non-structural flood control measures. More educated households are more receptive to strategies involving information dissemination, training, and support projects. This is because they are aware of the long-term benefits of non-structural approaches and the past failures of structural approaches.

The main source of income is fishing at 34% followed by trading at 32%. Crop and livestock farming are at 10% and 6% respectively. Bunyala is located closer to Lake Victoria hence flooding is frequent in this area due to the backflow from the lake, making farming less suitable. Okumu (2017) reports that fishing and subsistence crop and livestock farming have been the dominating economic activities in Busia County, however, households reported the flood destruction of crop fields and livestock hence reducing farming activities.

4.2 Perception of non-structural flood control measures among Households

This section addresses the first objective. It will first look into the flood frequency and effect then discuss the perceived effectiveness of the non-structural measures used by households.

4.2.1 Perceived flood frequency and effect among households

Flood frequency refers to the rate at which floods occur and flood effect refers to the intensity of a flood. Table 5 presents the results of the perception of households on the frequency and effects of floods.

Table 5: Flood frequency and flood effect in Bunyala sub-county

| | Frequency | Non- participants % | Frequency | Participants % | Aggregate group % |
|------------------------|------------------|------------------------------------|------------------|---------------------------|------------------------------|
| Flood frequency | | | | | |
| Always | 2 | 11.76 | 15 | 88.24 | 4.43 |
| Never | 21 | 95.45 | 1 | 4.55 | 5.73 |
| Often | 61 | 24.60 | 187 | 75.40 | 64.58 |
| Sometimes | 44 | 24.36 | 53 | 54.64 | 25.26 |
| Flood effect | | | | | |
| Severe | 62 | 34.64 | 117 | 65.36 | 46.61 |
| Moderate | 12 | 30.77 | 27 | 69.23 | 10.16 |
| Never | 19 | 21.11 | 71 | 78.89 | 23.44 |
| Slight | 35 | 46.05 | 41 | 53.95 | 19.79 |

On aggregate, 65% reported that floods occur often and 75% of them were participants in non-structural flood measures. Huho and Kosonei (2014) noted that the frequency of occurrence and severity of floods have been increasing over time. In Bunyala sub-county, land use change, climate shifts, and engineering activities of structures along rivers are the main causes of an increase in flood frequency. Odidi et al. (2020) also reported that the majority of households in Budalangi have experienced floods more than thrice in the past seven flood occurrences; others noted that it has become an annual experience.

Flood effects can be broadly categorized into two: flood damages and flood losses. Flood damages which are direct and tangible refer to physical destruction to public and private assets such as damage to infrastructure, buildings, and crops. Flood losses encompass secondary, tertiary, and intangible losses such as loss of human and livestock life, associated fatalities, and flood-related diseases (Otiende, 2009). On aggregate, about 47% of the households reported to have experienced severe flood damages and losses with 65% participating in non-structural flood control measures. This finding concurs with Opondo (2013) who found that 73% of households experienced severe effects with minor differences between income groups. The impact was mostly felt on the loss of human life and disruption of livelihood activities.

4.2.2 Perceived effectiveness of non-structural flood control measures

Table 6 presents the results of the household’s perception of whether or not the flood control measures were effective in mitigating flood effects.

Table 6: Effectiveness of non-structural flood control measures in Bunyala sub-county

| Usefulness | Frequency | Percent |
|-------------------------------------|------------------|----------------|
| EW information | | |
| No | 202 | 52.60 |
| Yes | 182 | 47.40 |
| Land regulations with zoning | | |
| No | 147 | 38.28 |
| Yes | 237 | 61.72 |
| Savings and credit schemes | | |
| No | 206 | 53.64 |
| Yes | 178 | 46.36 |
| Water harvesting | | |
| No | 245 | 63.80 |
| Yes | 139 | 36.20 |

Results in Table 6 show that about 53% of households reported that the early warning information was not useful. Most households opined that they did not believe the warning information because, in the past, it proved inaccurate. United Nations Development Programme (UNDP) (2018) notes that while KMD has made significant progress in developing and implementing FEWS in Kenya, challenges still exist concerning the effectiveness of the system. One key challenge was the limited capacity of this organization to effectively communicate flood warnings to vulnerable communities. This report recommended that KMD strengthen communication systems and engage local communities.

In land-use planning with zoning, about 62% of households reported that the practice was useful. This is because of the ease of applying the land practice. However, due to a lack of awareness and proper training, it was perceived by 38% of the households as inadequate. Odhiambo and Mihara (2017) similarly revealed that 74% of farmers in the Bunyala area are

familiar with land and water conservation practices yet only 43% put at least one practice to use. Increasing knowledge and adoption of these practices through training and extension services was recommended.

For saving and credit schemes, about 54% of the households reported the practice as not useful. This is because often, their savings cover consumption expenditure and fail to recover valuable assets. Due to high household sizes, households tend to save very little hence they fail to prioritize saving for flood risk. According to Shibia (2020), the use of financial instruments for drought and flood-prone areas as a coping mechanism is low. This is attributed to low and variable household incomes, financial illiteracy, high cost of credit and insurance premiums, and slow response of financial institutions to adapt products to drought and flood dynamics.

In water harvesting, about 64% of the households did not find it useful. The main form of water harvesting in Bunyala Sub-County is roof water harvesting with few households having implemented surface water harvesting, due to lack of efficient storage (Mugnier, 2021). Aroka (2010) admits that in rural Kenya, efficient water harvesting schemes are mainly implemented by actors such as the government and non-government institutions.

4.3 Extent and use of non-structural flood control measures and factors influencing the extent in Bunyala sub-county.

This section addresses the second objective. It presents findings on the extent and the factors influencing the use of non-structural flood control measures by households.

4.3.1 The extent of using non-structural flood control measures in Bunyala Sub-County

The extent of each non-structural measure was determined individually. The extent of using savings and credit schemes was determined by the number of flood events households had used their savings to mitigate floods; FEWS was determined by the number of flood events that the households used the early warning information to mitigate floods; land-use planning with zoning was determined by the frequency of using land protection practices to mitigate flood impacts and the extent of water harvesting was determined by the number of times the households harvested water to mitigate floods.

A 4-point Likert scale comprising of rarely-no extent (NE), sometimes-low extent (LE), often-moderate extent (ME) and always-high extent (HE) was used to measure extent as presented in Table 7.

Table 7: Extent of using Savings and Credit schemes to mitigate effects of floods in Bunyala sub-county.

| Response | Weight | Frequency | Percentage |
|----------------------|---------------|------------------|-------------------|
| Rarely(NE) | 1 | 212 | 55.21 |
| Sometimes(LE) | 2 | 120 | 31.25 |
| Often(ME) | 3 | 19 | 4.95 |
| Always(HE) | 4 | 33 | 8.59 |

Results in Table 7 show that only a small number (about 8%) would always use savings and credit schemes to pay for non-structural flood control measures while the majority of the households (55%) rarely use this measure. Hallegatte et al. (2016) revealed that poorer households are vulnerable to climate change and that savings and credit schemes are not a solution for them due to low incomes and high transaction costs.

Table 8: Extent of using FEWS to mitigate effects of floods in Bunyala sub-county

| Response | Weight | Frequency | Percentage |
|----------------------|---------------|------------------|-------------------|
| Rarely(NE) | 1 | 192 | 50.00 |
| Sometimes(LE) | 2 | 135 | 35.16 |
| Often(ME) | 3 | 30 | 7.8 |
| Always(HE) | 4 | 27 | 7.03 |

Results in Table 8 show that the majority (50%) of households rarely use FEWS as a mitigation measure while 35% sometimes use it. This low response is due to a lack of knowledge in using the information availed to them. United Nations Environment Programme(UNEP) (2012) suggested that households and communities be integrated into these early warning systems to open avenues for discussions hence helping them to build trust in the systems.

Table 9: Extent of Land-use planning with zoning to mitigate effects of floods in Bunyala sub-county.

| Response | Weight | Frequency | Percentage |
|-------------------|---------------|------------------|-------------------|
| Rarely(NE) | 1 | 164 | 42.71 |

| | | | |
|----------------------|---|-----|-------|
| Sometimes(LE) | 2 | 148 | 38.54 |
| Often(ME) | 3 | 36 | 9.38 |
| Always(HE) | 4 | 36 | 9.38 |

With about 43% and 39% rarely and sometimes using land planning measures to mitigate floods, it shows that the measure was poorly adopted (Table 9). According to WMO/GWP (2008), implementation of land-use planning measures remains challenging. First, due to the inaccessibility of data to low-income households on risks and hazards, hence limiting resilience initiatives. Secondly, there are no strong institutions that follow up on the enforcement of land management strategies and that seek to find out why households choose to live in flood-prone areas.

Table 10: Extent of Water harvesting to mitigate effects of floods in Bunyala sub-county

| Response | Weight | Frequency | Percentage |
|----------------------|---------------|------------------|-------------------|
| Rarely(NE) | 1 | 84 | 21.88 |
| Sometimes(LE) | 2 | 81 | 21.09 |
| Often(ME) | 3 | 109 | 28.39 |
| Always(HE) | 4 | 110 | 28.65 |

Water harvesting is the only flood control measure that cuts across all the response options. Findings in Table 10 show that the majority (about 29%) of the households always (HE) harvest water to mitigate floods and about 28% often (ME) use it. This is because households found it cheaper and could be adopted at small-scale levels. They could gain the direct benefits of harvesting water in their day-to-day activities. Comparatively, about 22% and 21% rarely and sometimes used water harvesting as a flood control measure. Tamagnone et al. (2020) recommend up-scaling water harvesting techniques to lessen flood hazards and land degradation.

4.3.2 Factors influencing the extent of using non-structural flood control measures in Bunyala Sub-County

This section presents multivariate analysis results on the factors influencing the extent of using non-structural flood control measures. The extent of savings and credit schemes, FEWS, land-use planning with zoning, and water harvesting were jointly treated as dependent variables

while household characteristics and flood experiences presented in Table 11 were treated as independent variables. Tables 12, 13, 14, and 15 present coefficient estimates from multivariate regression for each non-structural measure.

Table 11: Factors influencing the extent of using non-structural flood control measures in Bunyala sub-county

| Source | df | F-statistics | Prob>F |
|----------------------------|-----------|---------------------|------------------|
| Model | 10 | Wilk's 12.97 | 0.0000 |
| | | Pillai's 11.90 | 0.0000 |
| | | Lowley's 13.90 | 0.0000 |
| | | Roy's 29.88 | 0.0000 |
| Residual | 373 | | |
| Land ownership | 1 | 5.53** | 0.0002 |
| EW duration | 1 | 4.66** | 0.0011 |
| EW awareness | 1 | 4.82** | 0.0008 |
| Land reg. awareness | 1 | 13.42** | 0.0000 |
| Flood effect | 2 | 9.99** | 0.0000 |
| Consecutive floods | 1 | 16.64** | 0.0000 |
| Credit access | 1 | 8.34** | 0.0000 |
| Climate info access | 1 | 4.88** | 0.0000 |

** represents significance level at 5%

Table 11 presents the multivariate regression results of FEWS, savings and credit schemes, land planning with zoning, and water harvesting jointly. The F ratios and p-values for four multivariate criteria are given for Wilk's lambda, Lowley-Hotelling trace, Pillai's trace, and Roy's largest root. The results indicate that all the predictor variables significantly influenced the extent of using non-structural flood control measures at a 95% confidence interval; p-values<0.05.

According to Botzen et al. (2009), households that own land are more likely to participate in flood control measures in a quest to protect their property and mitigate financial losses that may be associated in the case of a flood event.

On early warning duration, Bubeck et al. (2012) note that it helps increase preparedness levels allowing households to activate their flood mitigation plans before the flood event. Other flood mitigation stakeholders also get ample time for decision-making and engaging communities. Knowledge and awareness shape households' behavior toward flood preparedness. Being aware and knowledgeable on early warning systems and land regulations increases understanding of the importance of flood mitigation measures hence increasing the desire to protect homes and belongings (Nyberg et al., 2020).

On flood effect and consecutiveness, perception of flood risk and past experiences often cause a profound emotional impact on households and these may cause households to intensify their use of flood control measures to cope with the emotional aftermath (Mulligan & Kipkemboi, 2017). According to Shibia (2020), households with access to credit and climate information can implement more effective measures hence reducing reliance on other institutions. However, Osberghaus (2017) warns that these factors alone may not be sufficient due to the presence of regulatory frameworks and social norms that are also crucial in influencing the extent of flood mitigation.

Table 12: Factors influencing the extent of using savings and credit schemes in Bunyala sub-county

| Variable | Coefficient | Standard Error | t | P> t |
|--------------------------------|--------------------|-----------------------|----------|-----------------|
| Land ownership-Yes | -.400** | .101 | -3.94 | 0.000 |
| EW duration->80 days | -.027 | .123 | -.022 | 0.825 |
| EW awareness-yes | -.019 | .103 | -0.19 | 0.849 |
| Land reg. awareness-yes | .179 | .103 | 1.74 | 0.083 |
| Flood effect | | | | |
| Moderately | -.350** | .155 | -2.26 | 0.024 |
| Never | -.605** | .143 | -4.24 | 0.000 |
| Slightly | -.546** | .119 | -4.60 | 0.000 |
| Consecutive floods-yes | .434** | .105 | 4.12 | 0.000 |
| Credit access- No | -.350** | .109 | -3.20 | 0.001 |
| Climate info access-yes | -.143 | .104 | -1.38 | 0.169 |

** represents significance levels at 5%

Table 12 presents the multivariate results of factors influencing the extent of using savings and credit schemes as a flood control measure. Land ownership, flood effect, consecutiveness of floods, and access to credit were found statistically significant at a 95% confidence level with a $p\text{-value} < 0.05$.

The coefficient of land ownership indicates that it is negatively associated with the extent of using savings and credit schemes; as land ownership increases, the extent of saving decreases. Most land in Busia County especially in the rural areas is communally owned hence saving towards preserving the land becomes a collective responsibility, which is risky since no particular person has the incentive to control its activities. Flood mitigation therefore may be less prioritized by some members due to these ownership conditions (Hallegatte et al., 2016).

Flood effect coefficients on all levels (moderate, never, slight) show that as the flood effect increases, the extent of saving decreases. In sight of a flood event, households tend to focus on their consumption first and savings become secondary until all their needs are met. OECD (2016) adds that due to the immediate expenses that floods cause and the loss of income due to the disruption of business activities, it is difficult for households-- to increase their savings towards this cause.

Consecutive floods refer to flood series that occur in close succession in the same area. The coefficient shows that an increase in the consecutiveness of floods causes an increase in the extent of savings. If left unattended, the incremental damage caused by intermittent floods results in destruction and this prompts households to increase their savings as a risk diversion strategy. However, Sultana and Rayhan (2012) contradicted this feeling arguing that consecutive floods affect financial preparedness and the ability to save for future flood events hence reducing the extent to save. Additionally, recovering from one flood to another can be costly hence straining budgets and leaving little to save.

The access to credit coefficient showed that as the lack of access to credit increased, the extent of savings decreased. It is intuitive to imply that borrowed credit is invested in activities that generate income that is put into savings. Bocher et al. (2017) results concur with these findings revealing that households with access to credit were more likely to improve their resilience to floods by taking up flood control measures using the credit and having enough to save from their incomes. However, Dercon and Christiaensen (2011) indicated that access to credit led to reduced savings and increased financial risks as households took on debt to cope with flood impacts.

Table 13: Factors influencing the extent of using FEWS in Bunyala sub-county

| Variable | Coefficient | Standard Error | t | P> t |
|--------------------------------|-------------|----------------|-------|-------|
| Land ownership-Yes | -.025 | .131 | 0.19 | 0.851 |
| EW duration->80 days | .018 | .158 | 0.12 | 0.907 |
| EW awareness-yes | -.515** | .133 | -3.86 | 0.000 |
| Land reg. awareness-yes | .222 | .132 | 1.68 | 0.093 |
| Flood effect | | | | |
| Moderately | -.179 | .199 | -0.90 | 0.367 |
| Never | .105 | .183 | 0.57 | 0.567 |
| Slightly | -.393 | .152 | -2.58 | 0.060 |
| Consecutive floods-yes | -.394** | .135 | -2.91 | 0.004 |
| Credit access- No | -.071 | .140 | -0.51 | 0.612 |
| Climate info access-yes | .067 | .133 | 0.50 | 0.616 |

** represents significance levels at 5%

The multivariate regression results of factors influencing the extent of using Flood Early Warning Systems (FEWS) as a flood control measure are presented in Table 13. There were only two variables that were significant in influencing the use of FEWS: early warning awareness and consecutive floods, both ($p < 0.05$).

Early Warning awareness coefficient showed a negative correlation implying that as awareness increases, the extent of using FEWS decreases. This is because, over time, households tend to get familiar with trends and expectations of early warning and can predict coming events more precisely. The search and use of formal flood early warning systems (FEWS) is thus reduced. Glago et al. (2019) opined that there is disconnect between the dissemination of early warning awareness information and the household's ability to act as per the directives.

Consecutiveness of the floods coefficient showed a negative correlation, as flood consecutiveness increases, the extent of using FEWS decreases. If flood early warning systems are not perceived as effective or reliable, households may be less inclined to use them. Also, in flood-prone areas, there can be a phenomenon known as 'disaster fatigue' whereby people become desensitized to warnings due to the frequency of alerts, hence decreased responsiveness to early warning systems. Additionally, consecutive floods disrupt the normal hydrological cycle resulting

in challenges in accurately predicting the magnitude, timing, and duration of subsequent floods (Kreibich et al., 2017).

Table 14: Factors influencing the extent of using Land planning with zoning in Bunyala sub-county

| Variable | Coefficient | Standard Error | t | P> t |
|---------------------------------------|--------------------|-----------------------|----------|-----------------|
| Land ownership-Yes | -.009 | .097 | -0.10 | 0.924 |
| EW duration->80 days | -.257** | .118 | -2.18 | 0.030 |
| EW awareness-yes | -.099 | .099 | -1.00 | 0.320 |
| Land regulation awareness-yes | ..564** | .098 | 5.72 | 0.000 |
| Flood effect | | | | |
| Moderately | -.273 | .148 | -1.84 | 0.067 |
| Never | -.560** | .136 | -4.10 | 0.000 |
| Slightly | -.430** | .113 | -3.79 | 0.000 |
| Consecutive floods-yes | .494** | .100 | 4.90 | 0.000 |
| Credit access- No | .413** | .104 | 3.94 | 0.000 |
| Climate information access-yes | -.023 | .099 | -0.23 | 0.816 |

** represents significance levels at 5%

Factors influencing the extent of using land planning with zoning as a flood control measure are presented in Table 14. Six variables: Early Warning duration, land regulation awareness, flood effect, consecutive floods, and access to credit were found statistically significant; p-values<0.05 at a 95% confidence level.

Early Warning duration is negatively correlated with the extent of land-use planning with zoning; as the EW duration increases beyond 80 days, the use of land regulations with zoning decreases. When the lead time for early warning systems for natural disasters is long, households may perceive a lower immediate risk hence complacency and procrastination in implementing land use planning measures. This is contrary to Omran's (2016) findings which indicate that the longer the EW duration, the more time there is to plan and prepare hence increasing the extent of land-use regulations.

Land regulation awareness is positively correlated to land-use planning with zoning. An increase in land regulation awareness increases the use of the measure. Awareness among communities encourages responsibility and the desire to effectively implement land regulation measures. According to the Associated Programme on Flood Management (2016), land regulation awareness can help prepare communities to better respond to flood events hence reducing property and infrastructure damage and eventually restoring natural ecosystems.

Consecutive floods and flood effects are both positively correlated to the extent of using land-use regulations. As flood consecutiveness and effect increase, the extent of using land regulations also increases. High flood consecutiveness and effect necessitate households to increase the implementation of zoning regulations to minimize exposure and impacts of flood hazards. Contrary to this, when floods are consecutive they cause severe effects on land availability and suitability hence limiting the utilization of land regulation practices (Der Sarkissian et al., 2022).

Access to credit was positively correlated to the extent of land-use regulations; an increase in access to credit increases the extent of using land-use regulations. Access to credit provides resources that incentivize land development leading to increased demand for zoning and planning regulations. According to Domeher and Abdulai (2012), access to credit enables land owners to implement land planning activities and choose the scale and scope of implementation. However, access to credit varies based on economic conditions, local regulations, state of land ownership and size of land

Table 15: Factors influencing the extent of using Water harvesting in Bunyala sub-county

| Variable | Coefficient | Standard Error | t | P> t |
|--------------------------------|--------------------|-----------------------|----------|-----------------|
| Land ownership-Yes | .167 | .109 | 1.53 | 0.126 |
| EW duration->80 days | .406** | .132 | 3.07 | 0.002 |
| EW awareness-yes | .160 | .111 | 1.44 | 0.152 |
| Land reg. awareness-yes | .591** | .110 | 5.34 | 0.000 |
| Flood effect | | | | |
| Moderately | .380** | .167 | 2.28 | 0.023 |
| Never | .913** | .154 | 5.94 | 0.000 |
| Slightly | .539** | .128 | 4.23 | 0.000 |

| | | | | |
|--------------------------------|---------|------|-------|-------|
| Consecutive floods-yes | .708** | .113 | 6.24 | 0.000 |
| Credit access- No | -.208 | .118 | -1.77 | 0.078 |
| Climate info access-yes | -.481** | .112 | -4.30 | 0.000 |

** represents significance levels at 5%

Table 15 presents multivariate regression results of factors influencing the extent of using water harvesting as a flood control measure. The significant factors were: early warning duration, land regulation awareness, flood effect, consecutive floods, and access to climate information with p-values<0.05 at 95% confidence level.

Early Warning (EW) duration had a positive correlation to the extent of water harvesting, as EW duration increases, the extent of harvesting water also increases. Longer early warning duration provides households with more time to decide on the scale and construct water harvesting structures. UNISDR (2002) attributed this to the ability of households to prepare their water harvesting tools early in anticipation of rain when the EW information is given early enough. The land regulation awareness coefficient is positive implying that as land regulation awareness increases, the extent of harvesting water also increases. Land regulation awareness plays a crucial role in shaping the feasibility and sustainability of water harvesting projects by ensuring the initiatives are carried out in an environmentally responsible way. Additionally, harvest water in the hope of reducing flooded water around the household area.

Flood effect and consecutiveness had a positive correlation with water harvesting, implying that the more the effect and consecutiveness of floods, the more the extent of harvesting water. They provide opportunities for freely available water to be collected. Sepehri et al. (2018); and Tamagnone et al. (2020) agree that flood effect and consecutives give a chance to harvest water in bulk to be used during dry seasons for the growing populations. However, there is limited profitability of water harvesting designs under local conditions.

Access to climate information has a negative correlation with the extent of water harvesting; as access to climate information increases the extent of harvesting water decreases. This may be so when the climate information is not timely or does not suit the needs of the affected community. Ncoyini et al. (2022) suggest that accessibility of climate information improves the capacity to effectively harvest water when households get information on when to collect water, how much to collect, and how to manage their water resources.

4.3.3. Multivariate regression test for multicollinearity

Multicollinearity refers to a situation where two or more independent variables are highly correlated with each other. This correlation makes it difficult to determine the individual effect of each predictor on the dependent variable, which can lead to several issues in the analysis. Multicollinearity does not affect the predictive power of the model as a whole, but it undermines the ability to understand the role of individual predictors, which is crucial in explanatory models where interpreting coefficients matters (Shrestha, 2020). Addressing multicollinearity ensures better reliability and clarity in multivariate analyses. The Variance Inflation Factor (VIF) is the most common metric to detect multicollinearity. It helps ensure that the model's predictor variables are sufficiently independent from one another and allows improvement in model accuracy and interpretability, ensuring that the estimated regression coefficients reflect the true relationships between predictors and the outcome. A VIF greater than 10 suggests problematic multicollinearity (Oke et al., 2019). Below are the vif results from the multivariate analysis.

Table 16: VIF test results for multicollinearity

| Variable | VIF | 1/VIF |
|-----------------------------------|-------------|---------------|
| Land Ownership | 2.32 | 0.4310 |
| EW duration | 1.76 | 0.5681 |
| EW awareness | 3.68 | 0.2717 |
| Land regulation awareness | 1.55 | 0.6451 |
| Flood Effect | 3.01 | 0.3322 |
| Consecutive floods | 4.23 | 0.2364 |
| Credit access | 1.26 | 0.7937 |
| Climate Information Access | 1.97 | 0.5076 |
| Mean VIF | 2.47 | 0.4049 |

The results above show that the mean VIF was below 10. The conclusion is that there was no multicollinearity detected.

4.4. Impact of non-structural flood control measures on household consumption expenditure in Bunyala sub-county

This section addresses the third objective. It presents findings on the estimation of probability propensity scores, region of common support, estimation of average treatment effects, and a test on covariate balance.

4.4.1 Estimation of the Probability Propensity Scores

The results in Table 16 show the estimated propensity scores for selected covariates affecting participation and household consumption expenditure. This was done using probit regression.

Table 17: Probit estimation of factors influencing the decision to participate in non-structural flood control measures in Bunyala Sub-County

| Participation | Coefficient | Standard Error | z | p> z |
|--|--------------------|-----------------------|----------|-----------------|
| Social group | -0.489** | .086 | -5.67 | 0.000 |
| Climate info access | 1.09** | .232 | 4.73 | 0.000 |
| Household head age | -.004 | .015 | -0.26 | 0.795 |
| Household size | .059 | .066 | 0.90 | 0.369 |
| Household head gender | -.462 | .297 | -1.56 | 0.120 |
| Marital status | -.124 | .141 | -0.98 | 0.326 |
| Education | .206 | .149 | 1.37 | 0.170 |
| Occupation | -.296** | .075 | -3.92 | 0.000 |
| Land ownership | .571** | .249 | 2.28 | 0.022 |
| EW duration | 1.59** | .369 | 4.31 | 0.000 |
| Savings | .151 | .313 | 0.48 | 0.629 |
| Flood frequency | -.113 | .145 | -0.78 | 0.435 |
| Flood effect | -.236** | .102 | -2.31 | 0.021 |
| Consecutive floods | .534** | .239 | 2.24 | 0.025 |
| Credit access | .555 | .339 | -1.64 | 0.101 |
| _cons | -.366 | 1.57 | -0.23 | 0.815 |
| Number of obs= 326, LR chi2(15) = 174.28, Prob>chi2 = 0.0000, Pseudo R2 = 0.4319 | | | | |

**** represents significance levels at 5%**

The results in Table 17 show a Pseudo of 43.19% which indicates that the estimated model performed well under the nearest-neighbor matching method. The low Pseudo shows that households that participated in non-structural flood control measures and those that failed to participate overall have similar characteristics hence making it easy to find good matches between the treated and control group. The probability value of 0.0000 implied high significance levels of covariates in the model, hence, the regression coefficients are not equal to zero.

Considering the p-values of the fifteen covariates in Table 16, belonging to a social group, access to climate information, household head occupation, land ownership, EW duration, flood effect, and flood consecutive were found statistically significant in influencing the households' decision to participate in flood control measures.

An increase in households joining a social group reduces their probability of participating in non-structural flood control measures by 48.9%. Social groups are formed with different objectives which may overshadow flood control. Babicky and Seebauer (2017) found that while social ties are effective when responding to and recovering from floods, the expectation of social support downplays risks, making precautionary actions by individual households less likely.

Access to climate information increases the probability of participating in non-structural flood control measures by 109%. Access to climate information gives households the direction and motivation to adopt flood control measures in their various capacities. According to Cherotich et al. (2012), climate information and support services play a crucial role in increasing awareness for building capacity and disaster preparedness for a changing climate. However, the choice of dissemination channels can influence access and use of climate information, hence affecting response capacities. Additionally, barriers of poverty, lack of infrastructure, illiteracy, and socio-economic factors could limit information sharing and utilization.

Household head occupation was found to have a decreasing effect on the probability of households participating in non-structural flood control measures by 29.59%. Occupation affects participation in flood control measures through factors such as time availability, knowledge, and financial resources. According to Paul and Routray (2009), low-income occupations meant limited financial capacity making it difficult for households to participate in flood control measures. On

the other hand, high-income occupations created time constraints with tight work schedules hence little interest in community-engaging programs focused on dealing with flood impacts

Owning land increased the probability of households participating in non-structural flood control measures by 57.05%. Land ownership allows both temporary and permanent development to be carried out including flood control measures. Charoenkalunyuta (2011) found that flood damage can be costly in terms of property damage and potential income loss. Additionally, landowners may have access to resources such as information, expertise, and financial capital which can be instrumental in implementing flood control measures.

Early warning duration increases the likelihood of households participating in non-structural flood control measures by 159%. Early warning duration helps in improving the preparedness of households. It also allows households to better understand the severity and potential impacts of impending floods. Additionally, households can be able to take part in community outreaches and engage local authorities, emergency management agencies, and community organizations in flood control efforts (Acosta-Coll et al., 2018).

The flood effect was found to decrease the likelihood of households participating in non-structural flood control measures by 23.55%. From experience, households know the effect of floods even when flood control measures are in place. The perceived ineffectiveness of flood control measures may discourage households from participating. These results contradict Tyler et al. (2021) who found that flood effects resulting in property damage, financial losses, and endangerment of personal safety and well-being would serve as a strong incentive for participation in flood control measures.

Flood consecutiveness was found to increase the likelihood of households participating in non-structural flood control measures by 53.43%. When floods occur frequently, the effects shape the households' perception of risks, willingness to invest in mitigation measures, and overall preparedness. Kuang and Liao (2022) suggested that heightened risk perception, significant economic losses, social cohesion, and community resilience motivate households and communities to take proactive measures to protect themselves from flood effects.

4.4.2 Region of Common Support and test for covariate balance

After the estimation of propensity scores, an optimal number of blocks is identified, in this case, there were seven regions. This is done to ensure the mean propensity score is not different between the treated and control groups in each block. When the balancing property was satisfied,

the region of common support was selected. These scores lie between 0.189 and 0.996 as indicated in Table 17. Observations of participants and non-participants within the region of common support were compared. Matching takes place only in the region of common support (Raufu et al., 2016). Therefore, observations showing propensity scores below 0.107 and above 0.999 were discarded.

Table 18: Distribution of region of common support for treated and control groups

| Inferior of block of p-scores | Participation | | Total |
|--------------------------------------|----------------------|-----|--------------|
| | 0 | 1 | |
| 0.1896932 | 13 | 3 | 16 |
| .2 | 13 | 9 | 22 |
| .4 | 18 | 18 | 36 |
| .6 | 14 | 43 | 57 |
| .8 | 10 | 25 | 35 |
| .9 | 3 | 28 | 31 |
| .95 | 0 | 99 | 99 |
| Total | 71 | 225 | 296 |

Table 18 reports the distribution of observations in the region of common support. From 128 non-participants (control group), 57 were dropped from the analysis; these are observations whose propensity scores were below and above the minimum and maximum scores Caliendo and Kopeinig (2008), while 71 were retained. For the participants (treated group), 31 observations were dropped while 225 were retained, hence a 1:3 ratio (control versus treated). Austin (2010) notes no one size fits all in choosing ratios, however, the primary goal of propensity score matching (PSM) is to eliminate bias in covariates between the treated and control groups (Ralph, 1998). To confirm there is no bias, the covariate balance box plot was used to visually inspect whether the distribution of covariates was similar between the two groups.

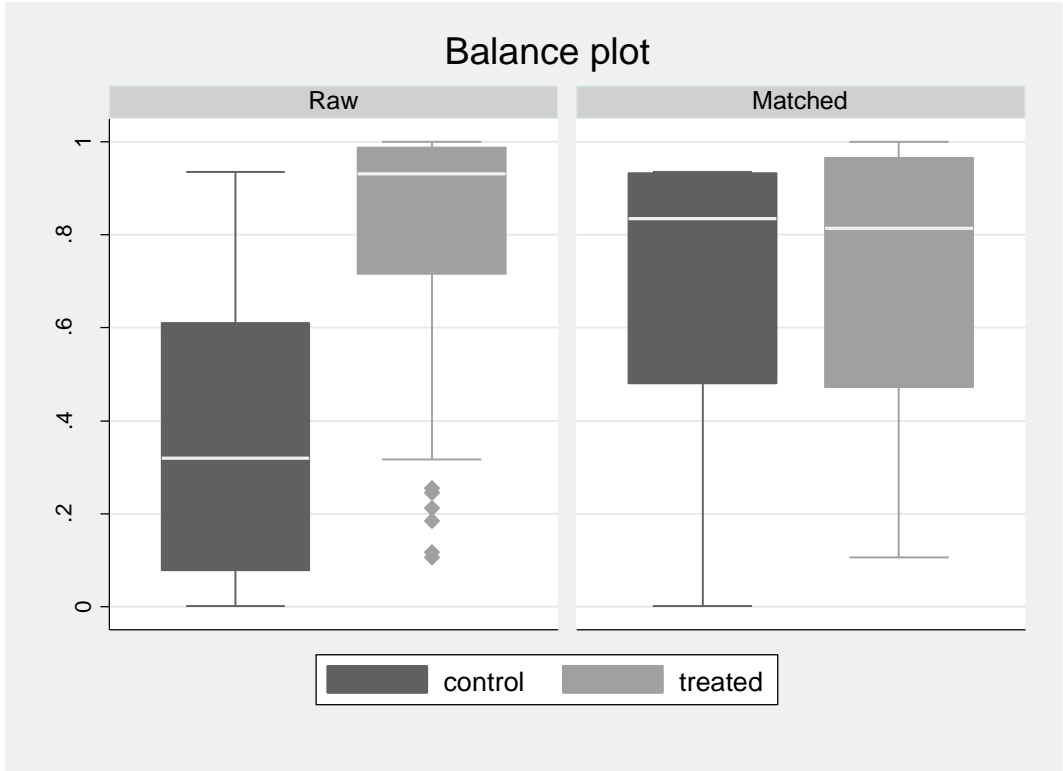


Figure 3: Covariate balance on propensity score

Figure 3 reports the covariate balance using propensity scores. The factors used are as follows: household occupation, household size, education level, household age, savings, and access to credit, gender, monthly income, flood frequency, early warning duration, consecutive floods, and land ownership. A perfectly balanced covariate has a standardized difference of close to zero and a variance ratio of close to one (Peter, 2009).

The boxes represent the distribution of covariates for each group. The vertical line inside each box represents the median value of the covariate groups. Ideally, the boxes should be almost similar in length and their medians (vertical lines) should be close to each other. This suggests a balance in covariates between groups. A covariate balance between the control and treated groups ensures that any observed treatment effects are more likely due to the treatment itself and not confounding variables (Harder et al., 2010). The conclusion therefore is that despite the matching ratio, the covariates were well balanced and distributed in matching the participants and non-participants.

4.4.3 Average Treatment Effects on household consumption expenditure

To determine the impact of participating in non-structural flood control measures, the average monthly household consumption expenditure for participants and non-participants was compared. Matching between these two groups was attained through the nearest neighbor matching method with replacement. This is because this method is considered simple and in case the nearest neighbor is far in terms of propensity scores, a replacement can be found.

The household expenditure was aggregated from the following expenses: food items, toiletries, housing and energy, healthcare, education, transport and communication, insurance, gifts, donations, and church offerings.

Table 19: Average Treatment Effect (ATE) on household consumption

| Monthly expenditure | Coefficient | AI Robust Standard Error | z | P> z | [95% Conf. Interval] | |
|----------------------------|-------------|--------------------------|-------|-------|----------------------|-----------|
| ATE | -3860.703 | 794.3921 | -4.86 | 0.000 | -5417.683 | -2303.723 |
| Participation (1 vs. 0) | | | | | | |

Table 18 shows that there is a significant difference ($z > 1.96$) in the household expenditures of participants and non-participants at a 5% significance level. Participants are seen to have their consumption expenditure reduced by Ksh 3860.703 compared to non-participants. It can be therefore concluded that non-structural flood control measures have a positive impact on welfare. Thielen et al. (2016) indicated that adaptation of non-structural flood control measures was able to reduce negative flood impacts by 30% and also termed these measures as no-regret measures. Anita (2013) added that non-structural flood control measures are effective in dealing with flood impacts and damages without significant environmental changes. Dawson et al. (2011) however mention that the effectiveness of non-structural flood control measures is sensitive to socio-economic changes and governance arrangements.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study concludes the following:

- i. Land use planning with zoning was perceived to be the most useful non-structural flood control measure, followed by Flood Early Warning Systems (FEWS), then savings and credit schemes, and finally water harvesting.
- ii. The extent of using non-structural measure showed that savings and credit schemes was not used at all. Flood Early Warning Systems (FEWS) and land planning with zoning were used to a low extent while water harvesting was the most widely used measure.
- iii. The factors that influenced the extent of using non-structural measures were: Early Warning (EW) duration, flood frequency, flood effect, EW awareness, flood savings, land regulation awareness, credit access, climate information access, receiving EW, and water harvesting initiative. The model was statistically significant and all the variables were found significant ($p > 0.05$).
- iv. Further into each non-structural measure: the extent of using savings and credit schemes was influenced by land ownership, flood effect, consecutiveness of floods, and access to credit. Flood Early Warning Systems (FEWS) was influenced by Early Warning (EW) awareness and consecutiveness of floods. The extent of land-use planning with zoning was influenced by Early Warning (EW) duration, land regulation awareness, flood effect, consecutiveness of floods, and access to credit. Finally, the extent of water harvesting was influenced by Early Warning (EW) duration, land regulation awareness, flood effect, consecutive floods, and access to climate information.
- v. The Propensity score matching (PSM) results suggested that belonging to a social group, access to climate information, household head occupation, land ownership, Early Warning (EW) duration, flood effect and consecutiveness of floods influenced the probability of households participating in non-structural flood control measures. There was a significant difference in household consumption expenditure between households that participated in non-structural flood control measures and those that did not. Average Treatment Effect (ATE) revealed that consumption expenditure for participants was Ksh.3860.79 less than that of non-participants.

5.2 Recommendations

The recommendations outlined will provide a framework for improving the use of non-structural measures efficiently and attaining low household consumption expenditures.

For the non-structural flood control measures to be useful, effective, and sustainable, there is a need to shape households' perceptions and this can be done through raising awareness on the benefits of these measures.

To encourage and increase the extent of using non-structural flood control measures the following needs to be done:

- i. The Kenyan Government together with Kenya Meteorological Department (KMD) should look into improving the Flood Early Warning (FEW) system and technology. This will help improve on accuracy and timeliness of giving Early Warning information.
- ii. Local authorities and Community Based Organizations should be involved by national government and NGOs in raising awareness on land regulation measures and suitable water harvesting designs so as to build confidence in taking up these measures and continually using them.
- iii. Households need to be educated on financial management before, during, and after flood experiences. Local authorities should take the initiative to involve financial institutions, NGOs, and CBOs in introducing this aspect of flood management taking into consideration the various income groups.

5.3 Further research

This study only focused on four non-structural measures, in Bunyala using cross-sectional data. Since these variables keep on changing there is a need to conduct a study based on time-series data. Also, increasing the sample size can help determine real impacts.

Further research on non-structural flood control measures can be conducted in other flood-prone areas in the country focusing on other kinds of floods such as flash floods and coastal floods.

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APPENDIX

Appendix A: Household Survey Questionnaire

This questionnaire was prepared to gather data for the study on the extent of use of non-structural flood control measures and their impact on household welfare. The data collected covered the household perception of non-structural measures, the extent of use of these measures, and their impact on household welfare. This research was conducted by Rita Shilisia, a student at Egerton University. The interview took approximately one hour. The information gathered was therefore for academic purposes and strictly confidential.

Section A: General information

Date...../...../.....

Name of enumerator.....

Sub-location.....

Questionnaire number.....

Respondent/Household
name.....

Section B: Household profile

| Household characteristics | head | Coding | Response |
|---------------------------|------|--|----------|
| Household head gender | | 1=male 0=female | |
| Household head age | | Number of years | |
| Marital status | | 1=single2=married3=divorced4=widowed 5=other(specify) | |
| Education level attained | | 1=primary2=secondary3=tertiary 4=none | |

Household head main occupation 1=farmer2=government sector3=private sector4=self-employed5=unemployed6=other(specify)

The main source of income 1=crop farming2=livestock and poultry keeping3=trading4=fishing5=salaried employee7=retired8=other(specify)

Household size
 Males Adults: ___ Children: _____
 Females Adults: ___ Children: _____
 Total

Section C: Land ownership details

C.1 Do you own land? (1=Yes 0=No) _____

If yes, complete the table for tenure systems employed

| Total size | Rented in | Rented out | Owned | Communal |
|------------|-----------|------------|-------|----------|
| Acres | | | | |

Section D: Perception of Non-Structural Measures

| Details | Coding | Response |
|---|---|----------|
| D.1 What is the frequency of your flood experience? | 1=never 2=sometimes 3=often 4=always | |
| D.2 How much were you affected by the floods? | 1=never 2=slightly 3=moderately 4=extremely | |

D.4. Flood Early Warning Systems(FEWS)

- D.41 Are you aware of the early warning system set up in Western Kenya? 1=Yes 0=No
- D.42 If yes, how did you get to know about it? 1=radio 2=television
3=social group
4=community leaders
5=other(specify)
- D.43 Have you ever received any warning information about impending floods? 1=Yes 0=No
- D.44 What was the duration of the flood warning? Hours
- D.45 Did you respond to the warning? 1=yes 0=no
If not, why?
- D.46 If yes, was the warning information useful? 1=yes 0=no
- D.48 In how many experienced flood events have you responded to the early warning? 1=none 2=a few
3=several 4=all

D.5. Land use planning with zoning

- D.51 Are you aware of any land use and zoning policies? 1=yes 0=no
- D.52 Have you ever been informed of proper land use measures? 1=yes 0=no

- D.53 If yes, how often are you sensitized on proper land use measures? 1=never 2=rarely
3=occasionally
4=frequently
- D.54 What is the source of information? 1=public extension officer 2=private extension officer
3=media 4=village leaders 5=neighbors
6=others(specify)
- D.56 How often do you practice these land regulations? 1=never 2=sometimes
3=often 4=always
- D.57 Do you think these practices help to mitigate negative flood events? 1=yes 0=no

If not, why?

D.6. Savings and/or Credit Schemes

- D.61 Do you have any form of savings and/or credit scheme? 1=yes 0=no
- D.64 Have you used these savings and/or credit to cover for losses during floods? If not, why? 1=yes 0=no
- D.65 Has insuring from floods proved useful? 1=yes 0=no
- If not, why?
- D.66 In how many flood events have you used your savings or credit? Number

D.7. Water harvesting

- D.71 Do you practice water harvesting in any form? 1=yes 0=no
- D.72 If yes, what is the form of water harvesting? 1=small scale 2=large scale
- D.73 What was the source of the initiative? 1=self 2=social group 3=project 4=other(specify)
- D.74 What was the cost of setting up the water harvesting system? Ksh
- D.75 In how many flood events have you harvested water? Number
- D.76 Has it been useful in mitigating the effects of floods? 1=yes 0=no
If not, why?

Section E: Institutional factors

E.1. Access to credit

- | Details | Coding | Response |
|---|------------|----------|
| E.11 Do you have access to any credit services? | 1=Yes 0=No | |
| E.12 Did you acquire any credit in the last flood experience? If no, proceed to F.2 | 1=Yes 0=No | |

E.14 What is the source of the loan? 1=bank2=microfinance
institution3=SACCO
4=shylock5=self- help
group6=family
member7=friend8=other(specify)

E.15 How much did you use in Ksh
employing non-structural
measures?

E.2. Belonging to a social group

| Details | Coding | Response |
|---|--|----------|
| E.21 Are you a member of any social group? | 1=Yes 0=No | |
| E.22 What kind of group are you in? | 1=farmergroup2=multi- purpose group3=youth group4=savings group5=community based organization6=others(specify) | |
| E.23 For how long have you been in the group? | Number in years | |
| E.24 What was the purpose of joining the group? | 1=trainings2=market access3=financial services4=input access5=access to information6=other(specify) | |

E.3. Access to climate information

| Details | Coding | Response |
|--|---|----------|
| E.31 Do you have access to climate information? | 1=Yes 0=No | |
| E.32 For how long have had this access? | Number in years | |
| E.33 How often do you receive information? | 1=once 2=twice 3=more than twice | |
| E.34 What are the sources of information? | 1=government officials 2=NGOs 3=community based organizations | |
| E.35 Has the information positively affected how you employ non-structural measures? | 1=Yes 2=No | |
| E.35 If not above, what has compromised the reliability? | 1=inconsistency 2=little information 3=poor delivery 4=others(specify) | |

Section F: Household Consumption Expenditure

F.1 Non-durable goods

| | |
|-----------------------|--------------------------|
| F.11 Food expenditure | Value of purchases (Ksh) |
| Fruits and Vegetables | |
| Legumes and nuts | |

Dairy products (yogurt, ice cream, butter, cheese, milk powder, etc.)

Cereals (wheat, millet, sorghum, rice, maize, etc.)

Bread and flour

Meat, fish, eggs

Fats and oils

Spices and confectionaries(sweets, candy)

Non-alcoholic drinks

Alcoholic drinks

Tobacco products(cigarettes)

F.13 Housing and energy expenditures

Charcoal

Paraffin

Firewood

Electricity

Batteries

Monthly rent paid

Maintenance costs for owned house

F.2 Durable goods

Items

Value in Kshs

Electronic appliances

Furniture

Personal vehicle

Farm machinery

F.3 Services

| Items | Value in Ksh |
|---|--------------|
| F.31 Healthcare | |
| Hospital bills | |
| Medicine | |
| Traditional medical services and medicine | |
| F.32 Education | |
| School fees | |
| School attire | |
| Stationery and books | |
| Accommodation(boarding) | |
| F.33 Transport and communication | |
| Maintenance for a personal vehicle | |
| Car fuel | |
| Public transport | |
| Airtime | |
| F.34 Entertainment | |

Parties

Program subscriptions(TV)

F.35 Others

Insurance

Gifts and donations

Church offerings

Section G: Flood characteristics

For how long was the household area flooded?

Have you suffered three flood events consecutively?

Was the flood water contaminated with sewage or oil?

Appendix B: Research Permit

| | |
|--|---|
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| This is to Certify that Miss.. Rita Shilisia of Egerton University, has been licensed to conduct research in Busia on the topic: Extent of use of non-structural flood control measures and their impact on household welfare in Bunyala Sub-County, Busia County, for the period ending : 13/September/2022. | |
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Open Access Peer-Reviewed Chapter

Impact of Non-structural Flood Control Measures on Household Welfare in Bunyala Sub-County, Kenya

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Abstract

Floods are the most destructive water-related disasters considered to have dire consequences on the livelihoods of the affected population. Structural and non-structural measures have been implemented as mitigation strategies to help cope with these disasters. Given the magnitude of the disaster from floods in Busia county, multiple agencies have come into play with alternative mitigation strategies. The strategies which directly engage the participation of the community are non-structural, which include flood forecasting and early warning systems, land-use planning with zoning, savings and credit schemes, and rainwater harvesting. Despite the fact that non-structural measures are considered sustainable, households in Bunyala sub-county are still struggling with the negative impacts of floods. It is therefore of interest to establish the welfare gains or profits households derive from using these measures. Descriptive statistics were used to analyze the variables of interest. Propensity score matching (PSM) is used to determine the impact of non-structural measures on household welfare through STATA software. The key finding is that households that participate in non-structural measures have their consumption expenditure reduced compared to non-participants. This, then concludes that the non-structural flood control measures have a positive impact on household welfare.

Keywords: floods, non-structural measures, welfare, PSM

