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By

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Assessment of Flood Risks and Indigenous Knowledge Employed in Flood Management Along The River Gambia

Publicly defended on 1st April 2025 before the jury composed of:

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DEDICATION

To my beloved father and mother (both late), this thesis is for you and is your success, for your "training seed" is now a tree of hope to his generation. You gave me wings and taught me to fly, and now I am flying as you constantly desired for me. To my loving wife (Saffie Gomez Mendy), your constant encouragement, belief, and patience in me fueled my determination to see this thesis through. God bless you for me.

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ABSTRACT

Flood risk management in The Gambia faces significant challenges due to the increasing impacts of climate-related disasters, requesting innovative approaches that integrate both Indigenous knowledge (IK) and scientific knowledge (SK). However, studies examining the IK in flood disaster risk management remain scarce, as the current study is oriented towards the contribution of IK to flood risk management in The Gambia.

This research employed a mixed-methods design to assess flood risks and climate variation in The Gambia. Data collection included focus group discussions, interviews, and household surveys across 15 flood-prone communities in 7 regions. Thematic content analysis, geospatial tools, and statistical and qualitative software were used to analyze qualitative and quantitative data, resulting in a comprehensive flood risk map and insights into climate variation impacts.

This finding reveals that communities along the River Gambia use IK to manage flood risks in the face of increasing hazards. Local people are highly aware of different flood types, distinguishing between beneficial annual flooding and damaging extreme events. Environmental degradation, poor drainage, and climate change were identified as key factors contributing to flooding. Indigenous early warning systems, based on ecological and meteorological signs, were discovered to be helpful to communities preparing for floods. The findings also reveal various coping strategies, such as adjusting homes, changing livelihoods, and managing livestock, which are employed before, during, and after floods.

The geospatial analysis results categorize flood risk into five levels, with low-lying areas near river and urban zones facing the highest risks due to poor infrastructure. The very high risk covers 54.740 km² (2.632%); the high risk spans 1,791.300 km² (18.510%); the moderate risk 3,649.325 km² (37.710%); the low risk 3,471.748 km² (35.875%); and the very low risk 510.112 km² (5.271%). The results also highlighted the spatial extent of extreme flood events with buffer ranging from 75.5 to 172.5 meters emphasizing the need for urgent need to improve spatial planning.

A survey of 422 households shows that while most have experienced flooding (98.6%), there needs to be more preparedness, with only 2.1% receiving flood warnings. Additionally, climate change-related disasters are a significant concern, with flooding increasing the risk of agricultural losses by 8 times. The findings underscore the importance of integrating IK into flood risk management to enhance community resilience in The Gambia and the sub-region.

RÉSUMÉ

La gestion des risques d'inondation en Gambie est confrontée à des défis importants en raison de l'impact croissant des catastrophes liées au changement climatique, ce qui nécessite des approches innovantes qui intègrent à la fois les connaissances indigènes locales (IK) et les connaissances scientifiques (SK). Toutefois, les études portant sur les connaissances endogènes en matière de gestion des risques d'inondation restent rares. La présente étude se concentre sur la contribution des connaissances endogènes à la gestion des risques d'inondation en Gambie.

Cette recherche a utilisé une méthodologie mixte pour évaluer les risques d'inondation et les variations climatiques en Gambie. Les données ont été collectées à travers des discussions de groupe, d'entretiens et d'enquêtes auprès des ménages dans 15 communautés sujettes aux inondations dans 7 régions. L'analyse thématique du contenu, les outils géospatiaux et les logiciels statistiques et qualitatifs ont été utilisés pour analyser les données qualitatives et quantitatives, ce qui a permis d'établir une carte complète des risques d'inondation et d'obtenir des informations sur l'impact des variations climatiques.

Ces résultats révèlent que les communautés vivant le long du fleuve Gambie utilisent les IK pour gérer les risques d'inondation face à des dangers croissants. Les populations locales sont très conscientes des différents types d'inondations et font la distinction entre les inondations annuelles bénéfiques et les événements extrêmes dommageables. La dégradation de l'environnement, le mauvais drainage et le changement climatique ont été identifiés comme des facteurs clés contribuant aux inondations. Les systèmes autochtones d'alerte précoce, basés sur des signes écologiques et météorologiques, se sont révélés utiles aux communautés qui se préparent aux inondations. Les résultats révèlent également diverses stratégies d'adaptation, telles que l'adaptation des logements, la modification des moyens de subsistance et la gestion du bétail, qui sont utilisées avant, pendant et après les inondations.

Les résultats de l'analyse géospatiale classent les risques d'inondation en cinq niveaux, les zones de faible altitude près des rivières et les zones urbaines étant les plus exposées en raison d'infrastructures inadéquates. Le risque très élevé couvre une superficie de 54,740 km² (2,632 %) ; le risque élevé couvre 1 791,300 km² (18,510 %) ; le risque modéré 3 649,325 km² (37,710 %) ; le risque faible 3 471,748 km² (35,875 %) ; et le risque très faible une superficie de 510,112 km² (5,271 %). Les résultats mettent également en évidence l'étendue spatiale des inondations extrêmes, avec une zone tampon allant de 75,5 à 172,5 mètres, soulignant le besoin urgent d'améliorer la planification de l'utilisation des terres.

Une enquête menée auprès de 422 ménages montre que si la plupart d'entre eux ont connu des inondations (98,6 %), ils doivent être mieux préparés, car seuls 2,1 % d'entre eux ont reçu des alertes aux inondations. En outre, les catastrophes liées au changement climatique constituent une préoccupation majeure, les inondations multipliant par 8 le risque de pertes agricoles. Les résultats soulignent l'importance d'intégrer les IK dans la gestion des risques d'inondation afin d'améliorer la résilience des communautés en Gambie et dans la sous-région.

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LISTS OF ABBREVATIONS

AFOLU…….. Agriculture, Forestry, and Other Land Use

AHP…………. Analytical Hierarchy Process

BJL……………Banjul

CBDRR………..Community-Based Disaster Risk Reduction

CHIRPS……….Climate Hazards Group InfraRed Precipitation with Station Data

CRR……………Central River Region

DM…………….Disaster management

DR…………….Disaster Risk

DRM…………Disaster Risk Management

DRR…………..Disaster Risk Reduction

EWS…………..Early Warning System

FGD…………..Focus Group Discussion

GBoS…………Gambia Bureau of Statistics

GDP…………..Gross Domestic Product

GEE……………Google Earth Engine

GIS……………Geographic Information System

ICZM…………Integrated Coastal Zone Management

IPCC…………..Intergovernmental Panel on Climate Change

KM…………….Kanifing Municipal

LGA……………Local Government Area

IK……………….indigenous knowledge

LK……………….Local Knowledge

LRR………….Lower River Region

LULC…………Land Use and Land Cover

MCDA…………Multi-criteria Decision Analysis

NBR…………….North Bank Region

NDMA………….National Disaster Management Agency

NGO……………..Non-Governmental Organization

PCA……………..Principal Component Analysis

SK………………..Scientific Knowledge

SRTM…………….Shuttle Radar Topography Mission

TCA………………Thematic Content Analysis

TK…………………Traditional knowledge

UNDRR…………..United Nations Office for Disaster Risk Reduction

URR………………Upper River Region

WCR……………..West Coast Region

GENERAL INTRODUCTION:

1.0 General Introduction of the Research Topic

1.1 Introduction of the subject

Millions of people in developing countries are affected by riverine flooding because of the significant population exposure around the river basin and weak mitigation and adaptive mechanisms (Alfieri *et al*., 2018)**.** According to Yahaya (2008), flood disasters are seen as a primary natural hazard because of their devastating impacts on flood-prone areas. This has a long bearing on The Gambia as it is one of the developing countries battling the effects of flood**s.** The runoff in river catchment depends on how topography-geomorphology, soils and vegetation, land use and land cover, and climate changes interact (TRAORE, 2014). According to Ockelford *et al.* (2020), about 80% of ocean plastics are believed to be transported to river most networks. This, according to them, is causing microplastic contamination in river sediments, thus causing a global period of flooding along rivers.

The Gambia's most vulnerable areas to flooding are wetlands and lowlands, which include the riverine areas of the River Gambia and unplanned settlements within the urban areas (Kavegue & Eguavoen, 2016). As stated by the climate change knowledge portal and Think Hazard- The Gambia, The Gambia faces high river flooding hazards. This, according to them, is a damaged and life-threatening river flood that is likely to occur in a short time from now. This results from the high level of the hazard across the country, in which flooding accounts for 60% of weather/climate-related hazards. Around 20% of The Gambia is covered with wetlands and swamps, thus making the flood-prone areas hit by floods yearly during heavy rain (Hazard, 2020). The country has the least developed economy, thus making it highly dependent on re-export, tourism, and remittances from European countries or overseas (Review, 1996). The Gambia faces development challenges where it imports 60% of its staple food. The rise and fluctuation of food prices make many households more vulnerable to hazards (WFP, 2016). It is true that vulnerability leads to disaster. However, disasters result from vulnerability, which may be influenced by the social, economic, and political environment and not only by natural hazards (Keefe *et al*., 1976). In developing countries like The Gambia, the higher the poverty level, the more difficult it is to own land, thus leading them to settle in areas that are inundated or prone to natural hazards (Šaki *et al*., 2019).

The role of indigenous knowledge in disaster risk reduction is paramount. The indigenous knowledge in disaster risk reduction can cover from pre-disaster to post-disaster. In short, it covers the disaster management cycle activities as mentioned by Dube *et al.* (2015). Recently, local knowledge has been seen as the most powerful tool for disaster risk reduction. Integrating local knowledge into our disaster risk reduction will improve our DRR plans and involve the local community members as part of decision-making (Tran, Shaw *et al*., 2009). Indigenous knowledge is helpful to local rice farmers in CRR when predicting the climate and weather conditions, as stated Badgie (2018). According to Kasei *et al*. (2019), Indigenous knowledge is used by informal urban settlements to warn against flood risks in most African countries. They further concluded that people in Ghana depend on local indicators to forecast climate-related hazards. Ajiang (2019) indicated that the local people have some strategies to reduce the severity of flood disasters, thus helping them survive even post-flooding. Some strategies discovered during the research were growing short-time crops, boiling drinking water, raising the house from the ground, moving their livestock to safer areas, sowing quickly-grown crops, and sheltering in high places.

It is generally believed that forests are a significant driver in rain-making processes in the atmosphere. The reason is that forests contribute to the water vapour in the atmosphere through transpiration (Salas-Acosta *et al*., 2022). This makes areas without forest cover experience less rainfall than those with forest cover. It is good to know that water vapour in the atmosphere is necessary for rain-making, but one should know that its content is not a guide to the relative amount of precipitation. Zhang *et al*. (2001) asserts that the main controllers of evapotranspiration are rainfall interception, leaf area, and plant-available water capacity. They mentioned that the maximum effects of these factors depend mainly on vegetation, climate, and soil. They concluded that over 250 catchments worldwide show that in a given forest cover or area, there is always a good relationship between evapotranspiration and rainfall on a long-term average.

Climate change is one of the major challenges facing the word especially the lest developed countries like the Gambia. Different projections shows that an increase in both the frequency and magnitude of extreme climate events like flood (IPCC 2021). Despite the high level of vulnerability in African especially The Gambia, there is a unprecedented assessment of climate change research that show the successful local adaptation mechanism (Cabral *et al*., 2017). Many coastal communities in Africa are vulnerable to climate change impacts such as flooding and erosion of which are projected to increase in the coming years alongside with economic implications (Henderson *et al*., 2017) . It is important to note that the impact of climate change to local communities is beyond immediate threats to food insufficiency but climate change also affects availability (Descroix *et al*., 2018; Thompson *et al*., 2017), health (Beck-Johnson *et al*., 2017; Agusto *et al*., 2015), and human settlements, which are particularly exposed to floods, droughts, and heat waves (Kundzewicz *et al*., 2014). Accepting the important of IK towards having a best integrated climate change adaptation policy, most especially communities that depend on rain-fed agriculture, can help to attain the goal of Sustainable Development Goal (SDG)13.

1.2 Floods:

Floods are commonly understood as the inundation of large amounts of water on dry land as a result of a number of natural and human-induced activities and processes. The IPCC sees a flood as a situation where the amount of water stored in an area surpasses the amount that can be drained in that area (IPCC, 2021). Flooding is experienced in different forms such as riverine floods, coastal floods and flash floods and are determined by the geographical and hydrological characteristics of the region under the flood (Zhang *et al*., 2022). Flash floods for instance are instantaneous floods that are precipitated by heavy rains or sudden waterfall incidents (Smith *et al*., 2023). Floods are categorized according to these characteristics, cause, time of rising and the duration of the flood. Flash floods often take place within a couple of hours and are attributable to extreme precipitation, while riverine floods on the other hand can be triggered by a series of wet days or melted snow (Hankin *et al*., 2021). The coastal flood is from storm surges, in contrast, metropolitan flood is mostly worsened by the absence of good drainage during population concentration (Tariq *et al*., 2020).

River floods are triggered by heavy rainfall, snowmelt in upstream areas, or tidal influence from downstream (Triet *et al*., 2017). Surface conditions like soil, vegetation cover, and land use directly affect the runoff produced (Gitika & Ranjan, 2014). River floods happen when the river runoff volume exceeds local flow capacities, as stated by Mazalena *et al*. (2022). The river levels rise slowly, and the period of rising and falling is particularly long, lasting even months, particularly in areas with flat slopes and deltaic areas. In addition, the failure or lousy operation of drainage or flood control works upstream can also lead to riverine flooding**.** Settlements in low-lying areas, as mentioned by Jian *et al.* (2021), in the middle or lower reaches of rivers are especially exposed to extensive riverine floods. In most major river basins, flood plains are subjected to annual flooding. In addition, population growth, climate change, and deforestation due to the expansion of agricultural activities, as mentioned by Ayine *et al*. (2019), are exposing the river basin and triggering a flood.

Pluvial flooding can be seen as flooding generated from rainfall-procreated overland flow and pounding before the runoff enters any watercourse, sewer, or drainage system. It is vital to know that pluvial flooding differs from surface water flooding, and surface flooding is the term used to determine the accumulation or combination of flooding in urban areas in a heavy rain pouring situation. Pluvial flooding can also be differentiated from 'flash flooding, which can also be related to high-intensity rainfall (Falconer *et al*., 2009). These are of exceptionally high rainfall intensity and duration during the rainy season, sometimes caused by seasonal storms and depressions and exacerbated by saturated or impervious soils. Flash flood, even though they are a serious threat to lives yet, according to Gaume *et al.* (2009), remains an inadequately documented phenomenon in many parts of the world. Flash floods can genesis from a rapid gathering and release of runoff waters from high land areas. This can be a result of high rainfall, cloud bursts, and sudden break-up of an ice Jam (Mu *et al*., 2021). Prikryl *et al*. (2021) also examined and concluded that heavy rainfall leads to floods and flash floods most in the context of solar wind. These types of floods are caused by high tides and storm surges caused by tropical depressions and cyclones. Coastline configurations, offshore water depth, and estuary shape influence the intensity of coastal floods. Furthermore, high tides may impede the discharge of rivers and drainage systems, leading to local or riverine floods.

Causes of Floods

Causes of Floods occurs from a blend of different climatic, environmental and human factors. Identifying these causes is important in devising ways to reduce their occurrence.

Climatic Factors:

Heavy rainfall is one of the main causes of floods. According to O'Connell *et al*. (2023), torrential down pours cause flooding due to both natural and artificial drainage systems getting clogged by storm water runoff. In the same manner, flooding is also worsened in areas with snow-by-snow melt water. In spring, sudden temperature change occurs and therefore snow turned to water makes rivers too full, leading to overspill (Kundzewicz & Pińskwar, 2022). The occurrence of severe events brings great rainfall and flooding; the occurrences are due to changes in climatic conditions (IPCC 2021). Amplifying this trend is the increased risk of flooding due to the rise in sea levels resulting from global warming. The thermodynamic effect of global warming and melting ice sheets is raising sea level elevation which is contributing to recurrence of severe weather in the form of storm surges and incidents in low lying coastal areas harnessed with seas and rivers (Vousdoukas *et al*., 2020).

Environmental and Geographic Factors

The topography of the area is a contributing factor in deciding how much threat an area of flooding faces. What is more, low-lying regions, particularly adjacent to rivers, coasts, and other water bodies are susceptible to flood due to the natural water flow (Hankin *et al*., 2021). Water-absorbing capacity of the soil is also adversely affected by deforestation, which also increases the surface runoff in an area during heavy rains (Vanmaercke *et al*., 2021). Vanmaercke, however, stress that forests are important in a flood prone land as they facilitate water retention as well as absorb it therefore the absence of this vegetation may increase flooding more.

The natural uses of land have been replaced by human activities such as construction and expansion of industries, and this has increased the flood hazard. Roads and buildings, which are impermeable surfaces, do not allow the ground to absorb water thus more runoff is experienced (Tariq *et al*., 2020). Urban development in general, alters the way water ways work and so it interferes with the amount of discharge which occurs and physically decreases the drainage capability already supplied naturally.

Infrastructure or Human Factors

Increased risk for flooding is observed due to poor urban planning and lack of appropriate infrastructure for the control of floods. Most of these cities are not suitable enough regarding the installation of the appropriate drainage facilities to take in heavy downpours or storm surge. Moreover, flood risks can be raised beyond expected thresholds by the breach of existing reservoirs, levees, or even drainage systems that may lead to uncontrolled flow (Smith *et al*., 2023). Flooding such as to break down dams is one instance here that could trigger such events as for instance the wrong regions below the dam being drowned in water in quick succession due to the descending floodwaters. Climate change is also influencing the causation of floods. Consequently, portions that were not prone to flooding during the previous periods have recorded an upsurge in the incidence of floods.

Impact of Floods

Floods are the causes of widespread damages and have a wide range impacts on environmental, economic, and social systems.

Environmental Impacts

It causes the environment to degrade in a vast way. One of the major impacts is soil erosion caused by floodwaters removing the top layer of soil. This has severe implications for agriculture because they also wash billions of tonnes nutrient-rich topsoil away, causing soil to lose its nutrients and erode over time, preventing crops from growing (Vanmaercke *et al*., 2021). Floods also devastate natural habitats, especially wetlands, forests and other ecosystems essential for biodiversity (Zhang *et al*., 2022). Floodwaters frequently become carriers of pollutants, chemicals, and wreckage polluting water supplies and dislodging aquatic ecosystems. In other cases, chemical pollutants from industrial sites or pathogens released due to flooding of sewage systems in Tokyo can enter watersheds (Dottori *et al*., 2020). This contamination gives a big risks to both human and wildlife health.

Economic Impacts:

Flood is capable of causing a devasting economic impacts, especially on venerable societies in developing countries. The World Bank (2022) made an estimation that flooding is causing an annual economic loss of approximately $30 billions globally. Damages cause by flooding on roads, buildings, and bridges may take a long time before recovery can be fully done thus straining the local economic growth (Smith *et al*., 2023). Flooding is a huge interruption of supply chains, causes death of livestock and crops. It is able to reduce the productivity of agriculture resulting into food insecurity in the nation (Vanmaercke *et al*., 2021). Flooding can lead to a temporally or permanent closing of business especially minor or small-scale businesses that lack the capacity to recovery quickly. In developing countries such as The Gambia, economic recovery can be challenging due to limited access to resources for rebuilding and disaster preparedness (World Bank, 2022).

Social Impacts:

Floods social impacts cut across many areas as it can range from loss of lives, displacements, health and psychological effects. In extreme flood event, there can be fatalities especially in communities where the early warning systems are ineffective or not available (Smith *et al*., 2023). Displacement is also another major challenge posed by floodings where thousands of vulnerable people are forced to leave their homes. This situation can lead to a long term or short-term displacement depending on the duration of the flooding.

Fooding is causing a serious challenge to public risks as standing waters can serve as a breeding grounds for mosquitoes. This is in turn increasing the risk of malaria and dengue fever in flooded areas (Tariq *et al*., 2020). In addition, flood is another major source of drinking water source contamination. This always increase the level of waterborne diseases such as cholera and typhoid (Vousdoukas *et al*., 2020). Floods is causing psychosocial impacts such as stress and trauma related to losing love ones, homes livelihoods during the event. These psychological effects can persist long after the physical damage has been repaired during recovery stage, particularly in vulnerable communities (O'Donnell *et al*., 2021).

1.3 Problem Statement

Living with hazards is a reality of nature, but being vulnerable and at high risk is a choice one can make. Flood hazards can only be a disaster when people's vulnerability is high. In other words, it is a situation where vulnerability and risk are higher than the capacity level of any given society (Kumpulainen, 2006). Research carried out by Shaari *et al*. (2017) indicated that flood has a profound implication on the country's GDP growth. This is because floods are affecting the country's agricultural sector and the growth of the manufacturing sector directly or indirectly.

The Gambia is highly vulnerable to climate change-related disasters, with floods and dry spells affecting the country (Bojang *et al.*, 2020). As The Gambia has experienced the effects of climate change, the flood events could have been more severe in the future (Geest & Warner, 2015). Due to the increase in this flood hazard problem, decision-makers and disaster risk reduction experts have increased their demand for river basin flood information and digital maps of extended risk flood areas using GIS and remote sensing. This can only be achieved if the local people's Indigenous knowledge is heard in reducing, adapting, and mitigating flood risk in any given society.

However, despite the various research carried out and policies made towards combating this life-threatening hazard, over the last decade, the effects and impact of the flood are still visible and devastating as many researchers could not bridge the gap between flood hazard and the Indigenous knowledge in adapting to the impact of a flood. This hazard is a severe concern for rice field owners in the Central River Region (CRR), where the region is seen as the "food basket" of The Gambia, as mentioned by Bagagnan *et al*. (2019) and has a likelihood to jeopardize with the little effort made by local farmers in The Gambia. The risk and resilience of the local communities are critical concepts in this study. In light of this stark background, this research strives to provide more insights into indigenous knowledge in flood risk management and flooding risk areas and their impacts on The Gambia.

1.4 Significance of the Study

According to The Gambia National Climate Change Policy, disaster seasonal floods could occur along the River Gambia after an above-average rainy season(Penny Urquhart, 2016). This shows an indication that there is a need for flood hazard assessment to be done along the river Gambia. During wet seasons, excess precipitation triggers the river's flood stage, causing the flooded water to flow to the flood plains and onto the land and rice fields (M'koumfida *et al*., 2018). According to UK Essays (2018), in 1999 and 2003, there were severe flood events occurred in the Upper River and Central River Regions, affecting 13.1% of the country's population. This is also stated in the National Disaster Management Agency (NDMA) report that between 2002 and 2006, there were 65 flood-related disasters in The Gambia (NDMA, 2005). As reported by Roberto (1990), in recent years, The Gambia experienced a significant number of disastrous events of both natural and human origins, including floods and drought. The Gambia's provincial town of Kuntaur and its surroundings in the Central River Region (CRR) in the year 2019 experienced severe flooding, and the entire village was buried in heavy rain.

The need to examine the indigenous knowledge employed in disaster risk management and assess flood risks and impacts along the river Gambia is paramount in the country's disaster risk reduction approaches.

1.5 General Objective

Contribution of Indigenous knowledge to Flood Risk Management along the Gambia River.

1.6 Specific Objectives

1. To examine Indigenous knowledge of flood hazards in The Gambia.

2. To assess the flood risk of the communities in The Gambia.

3. To assess the flood impacts on the communities along the Gambia River.

4. To examine the perception of local people on the effect of climate change.

1.7 Thesis Outline

This thesis is organized into four chapters: a general introduction and a general conclusion. **Chapter 1** provides a review of the available literature. The chapter also provides an explanation of the key theoretical concepts and a discussion of the changing disaster paradigms. It further gave a detailed review of IK, floods, and present aspects of climate change. **Chapter 2** provides a rationale for the employment of the method. It went on to separate specific methodologies for specific objectives; hence, only some of the objectives employed the same research method. This chapter provided the study area map with a table showing the study communities covered in the FGD and survey questionnaires. This chapter also provided how the research was implemented in practice and how the collected data were analyzed.

Chapter 3 contains the results of this study. The results were presented in four sections. Section 1 explores the IK in flood risk management among local communities along the river Gambia, thus directly addressing *Objective 1*. Looking through a different lens of different angles, IK was presented into 3 stages: pre-flood IK, During-flood IK, and post-flood IK. Section 2 provided a detailed presentation of the flood risk map indicating where flood risk is very high, moderate, and low, representing *Objective 2*. The section also presents different maps of the slope, elevations, Land Use and Land Cover (LULC), soil types, rainfall, and distance from the river. Section 3 presents *Objective 3,* which explores the impact of floods on local communities. It went on to show the affected areas in the local communities. Lastly, Section 4 explores the results of the *Objective*, which looks at the local people's perception of the effects of climate change. **Chapter 4** is divided into sections that provide detailed discussions on each of the four sections per Objective. It also dives into contrasting the result to global research, pointing out some research gaps the thesis results present. The thesis ended with a general summary of the research. It also highlights the study's limitations and identifies further research areas.

CHAPTER 1

LITERATURE REVIEW

2.0 This section of the thesis presents essential literature on the subject matter.

2.1 Theoretical concepts in disaster risk management

As stated by Kelman (2018), the disaster risk management field is known for its many terminologies. Thus, definitions and terms are slightly different from one time and geographical location to another. However, to meet the requirement of this thesis's Objective, the key adapted concept of disaster risk management needs to be explained. Vulnerability and resilience in the disaster academic field have been the most argued or debated concepts. However, some of the universally adapted definitions and terminologies are briefly described in this chapter.

2.1.1 Hazard

To be able to meet the required and limit to the purpose of this thesis, the hazard can be explained as: "A cycle, peculiarity or human activities that might cause death-tall, injury or other health implications, property loss, social and economic disturbance or environmental destructions" (Ojima *et al*., 2023; UNDR, 2020).

As noted by UNDRR, (2015); ICMIF (2017), hazards have different types and can be triggered from different sources. Hazards can be human-induced (e.g. political crisis, social chaos, terrorism). As this thesis concentrated on, natural hazards can be (e.g. floods, drought, tsunamis, volcanoes, landslides, etc.). Additionally, to the human, induced hazards can be technological hazards. As the scope of the thesis focuses on flood as a natural disaster, flooding is viewed as the most devastating and life-threatening natural hazard (Monte *et al*., 2021; Keating *et al*., 2017). Flood is commonly defined as excess water that submerges the dry land temporarily (Flick *et al*., 2012; Schanze, 2011) We have different types of floods, such as costal, flash, fluvial, and pluvial floods. Coastal floods happen when the river experiences storm surges, hurricanes, and rising sea levels as a result of climate change (Takagi *et al*., 2016); flash floods are seen as the most deadly and occur in a very quick and fast manner where steep catchments trigger the speed of water runoff (Maqtan *et al*., 2022); fluvial floods can happen when the streams' and rivers' banks are overflow thus triggering the fluvial floods (Yin *et al*., 2021); pluvial happen highly prone urban settlements as a result of heavy rainfall where the drainage system of those settlements can no longer contain the water (Bulti & Abebe, 2020; Maksimović *et al*., 2009). Furthermore, there are compound flooding events, where coastal and fluvial floods occur simultaneously in coastal areas that are highly prone to both flood types, as mentioned by Robins *et al*. (2021).

2.1.2 Disaster risk

As mentioned by the United Nations Office for Disaster Risk Reduction (UNDRR), disaster is defined as: "A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic, and environmental losses and impacts" (UNDRR, 2020; Rohland & García-Acosta, 2020).

A disaster can happen when the risks of that given society are exposed. Disaster risk is a phenomenon that has been within society for a long and constantly changing process, as stated by Birkmann *et al*. (2015) and Twigg (2015). Limiting to the Objective of this thesis, disaster risk can be conceptualized from the formative work of Blaikie *et al*. (1994) and later expanded to Wisner *et al*. (2013). This school of thought views disaster risk (DR) to be as follows:

[1] DRR= H X [(V/C) – M,

H = hazard, V = Vulnerability, C= Capacity, and M= Mitigation and prevention. Wisner *et al*. (2013) emphasized that even though the equation is in the form of a mathematical formula, it does not represent an equation for calculation but instead, according to Kelman (2018) and Saha (2015), is a pseudo-quadratic equation (Fake equation). Disaster risk is also defined by other entities of disaster management as a result of hazard, vulnerability, and exposure (UNDRR, 2023; Lal *et al*., 2012; IPCC, 2012). UNDRR (2019) sees exposure as 'a situation of people, infrastructure, housing, production capacity and other tangible human assets located in hazard-prone areas'. Hence, vulnerability is inclusive of susceptibility to harm; exposure can also be seen under the term vulnerability, as seen in the work of Wisner *et al*. (2014). It is noted that exposure in most cases in the disaster risk assessment field can be easier to quantify and represent than vulnerability because one needs to account for the human presence in the environment (e.g. the population of the flood-prone area, housing that is within the slope prone to flood) unlike vulnerability, there is a need to represent both social, political and economic situation of that given areas. This concept is elaborated more in section 2.1.3.

2.1.3 Vulnerability

UNDRR defined vulnerability as " conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards" (UNDRR, 2023).

In the attempt to define vulnerability in this thesis, as there are many definitions, it is caused and maintained by the social, political, and economic environment as these are the determinants of an individual's life (Forbes-Mewett & Nguyen-Trung, 2019). Gaillard & Mercer (2013) and Gaillard (2008) stated that vulnerability in a local setting is mainly incurred by human activities such as governance and political systems that often cause the unjust distribution of social resources. For this reason, one can say that vulnerability stands for the situation in a society that leads to the hazard becoming a disaster, as stated by Terry Cannon (1994). In short, if hazards are interacting with a society that is not vulnerable, there will be no disaster in that society. So, hazards can only become a disaster when there is a presence of vulnerability and exposure.

Vulnerability is very dynamic as it varies over time and across different phenomena such as households, individuals, communities, regions, countries, and continents. This is because many things can confirm that an individual or a group of people is vulnerable (Vogel & O'Brien, 2004). Some of the factors that can specific the vulnerability of a given individual or group of people are gender (Fordham *et al*., 2011), age (Wong *et al*., 2019), sexual orientation, and identity (Gorman-Murray & Baganz, 2019; Rushton *et al*., 2019), being a member of an indigenous group (Smith & Rhiney, 2016), disability (Twigg *et al*., 2018), and status (Walters & Gaillard, 2014). All these factors mentioned above are very important to note when assessing the vulnerability of any given society or individual. Even though the poverty level of a society or an individual cannot be entirely related to their level of vulnerability, there is still a strong connection between poor individuals or society being more vulnerable to hazards than wealthy individuals or society (Fothergill & Peek, 2004). This is also proven by Hallegatte *et al*. (2018), that poor societies/people are highly affected by hazards, often affected by disaster, and highly prone to hazards with less protection. Land prices are also seen to be a significant challenge to poor individuals in Africa, thus making them settle for areas that are ignored and referred to as disaster-prone (Hallegatte *et al*., 2020; Fernandez, 2011). These neglected areas, in most cases, will not have physical infrastructures that can mitigate the level of disaster impact in that area. It is evident that flood exposure causes poverty in a society (Rentschler *et al*., 2022).

2.1.4 Disaster Resilience

In the international discourse of disaster management, resilience is among the widely mentioned concepts in policy preparation and implementation (UNDRR, 2015a). Recently, the concept has become the critical focus point of many international donors for the global South countries as they focus on building the communities' disaster resilience (Ruszczyk, 2019). The concept of resilience in disaster science has evolved dramatically, as stated by Graveline and Germain (2022). With the popularity of the concept of resilience in contemporary disaster management research and practice, the term "Resilience", according to Weichselgartner and Kelman (2015), is yet to be a unanimously accepted definition. To achieve the Objective of this research, resilience is viewed as:

"A process that emphasizes the multiple ways in which a system can respond to hazard occurrence, including its ability to absorb hazard impacts, to learn from, adapt to and recover from them, and to reorganize after impacts" (López-Marrero & Tschakert, 2011).

I view this definition for two reasons.

1. This definition encompassed the capacity (i.e., coping and adaptive capacity of any society) and integrated the Local Knowledge of the society. This demonstrated that the capacity of a given society did not only form part of their resilience but also be seen as part of their building their resilience (Manyena *et al*., 2019; Manyena, 2006).
2. The definition also portrayed resilience as a "bouncing forward" instead of a "bouncing back" concept. Defining resilience in a way that views it as a process of going forward from the stage of the pre-disaster situation is very important (Mochizuki *et al*., 2018; Siambabala *et al*., 2011) because it demonstrates a stage of maintaining the trend of

development and transformative agenda of disaster risk management (Mavhura & Manyena, 2018).

However, there are many increasing critiques of the concept of resilience among disaster scholars. Grove (2014) and Mitchell (2013) insisted that resilience is influenced by a political agenda, thus making it difficult to bring about change during implementing the concept in disaster risk management. This may result in the resilience concept being less used in the future when a new disaster risk reduction word is introduced. All these are critiqued because it is believed that the romanticized word (resilience) does not involve the main power that is keeping the people vulnerable and does not take into consideration the factors limiting the communities' capacities to adapt to hazards (Tariq *et al*., 2021; Hanna *et al*., 2017; Sharifi & Yamagata, 2016). Recently, resilience has been challenged by not bridging the gap between resilience and the causes of risk, such as political segregation and environmental degradation (Mochizuki *et al.*, 2018). In addition, Ruszczyk (2019), in his argument, pointed out that even though the resilience agenda strives to upgrade the local communities' living conditions, the process of implementing the interventions on communities and individuals is drifting. It is also argued that it is challenging to implement resilience within the current neoliberal agendas, which shift responsibility away from those in power by shifting risks and responsibilities to local communities (Tierney, 2015; Kirmayer *et al*., 2009).

2.2.0 Disaster Risk Management Approaches

Over time, the causes of disaster have evolved in the disaster science field. The disaster, which was in the beginning seen as a result of the wrath of God, was later seen as a result of natural occurrence, now a holistic agreement in the field sees disasters being caused by human activities (anthropogenic disasters) (Furedi, 2009; Furedi, 2007). This has shown a paradigm shift in the field of disasters and the people's approach to disaster risk management. It has also helped in the risk reduction approach instead of adapting to the impact of disasters.

2.2.1 From managing disasters to managing disaster risks

Disaster management involves managing disasters and managing disaster risks. To achieve these concepts, there are three management strategies to put in place: disaster risk reduction (DRR), disaster management (DM), and disaster risk management (DRM). These strategies are explained in Table 1 below:

Table 1: Explanation of DRR, DM, and DRM by UNDRR

No:	Strategy	Explanation
1	Disaster risk reduction	Disaster risk reduction strives to strengthen resilience to achieve sustainable development goals. It focuses on mitigating current disaster risks and preventing disasters from happening.
2	Disaster management	The organization, planning, and application of measures preparing for, responding to, and recovering from disasters.
3	Disaster risk management	Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk, and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

The evolution of the disaster risk management field demonstrated that hazards can only affect people’s lives if there is vulnerability. I.e. in the absence of vulnerability and exposure, there is no disaster. Enenkel *et al*. (2017) pointed out that due to the development of the disaster field, the focus has shifted from a top-bottom disaster management approach to a bottom-top disaster management approach. As mentioned by Jones *et al*. (2015), DM places a key focus on management and responding and recovering from disaster. Zulfadrim *et al*. (2019) also stated that DRR and DRM are more proactive as they focus on prevention, mitigation, preparedness, and responses. In their view, DRR and DRM represent the disaster management cycle, which is widely accepted in the disaster science field. I tend to value DRR and DRM more than DM; hence, they focus more on "risk thinking" than DM. As noted by Bank (2013), risk management is a significant tool for sustainable development. Turap *et al*. (2013) and Arnold *et al*. (2012) also emphasized that risk management has a solid linkage with the development of any society. In other words, the more the risk is managed, the faster the development process of a society. Managing and reducing risk can be visualized in the disaster management cycle as the cycle comprises four approaches. The four components and disaster management cycle are shown in Figure 1 below.

1. Preparedness: Preparedness alludes to techniques and measures for planning for and lessening the effects of disasters, for example, early warning information identifying the risk, development of local warning systems, and community evacuation plans through community education and evacuation drills (Kohn *et al*., 2012);

2. Mitigation: Mitigation includes procedures and practices pointed toward diminishing the very probability or outcome of a disaster, for example, planning and zoning, floodplain protection, property acquisition and relocation, or public outreach projects (Scottish Water, 2020; Coppola & Coppola, 2015);
3. Response: Response includes methodologies to decrease the adverse effects of disaster and stay away from additional potential ramifications, for example, revitalizing the emergency operations centres, evacuating threatened populations, opening shelters, and providing mass care, emergency rescue, and medical care (Golding, 2022);
4. Recovery: Recovery includes viewpoints like relief, rehabilitation, and building back better (Ben Wisner *et al*., 2014); typically, it alludes to 'normalizing' and getting back to the pre-disaster conditions (Coppola, 2015), contemporary reasoning of recovery empowers the idea of 'building back better' (UNDRR, 2023).

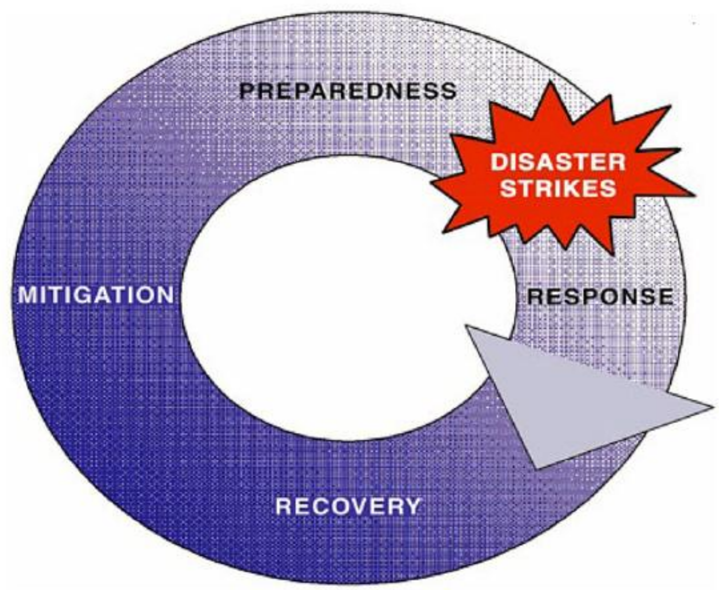

Figure 1: The four classical phases of the disaster management cycle, adapted from (Sawalha, 2020)

However, the recent disaster cycle has been received backslide by many scholars, stating that the cycle is elementary and does not address the complicity of disaster in the contemporary disaster science field. Twigg (2015) critique that the cycle does not address the current disaster challenges because of its simplicity. It is seen as a cycle that fails to portray the local peoples' knowledge in managing disaster; thus Weichselgartner and Obersteiner (2002) referred to it as a false representation of a proper disaster management approach; hence, disaster has grown into a complex phenomenon.

2.2.2 The top-down and hazard-centred to bottom-up and vulnerability-centered approaches

Disaster science literature has differentiated between the two main discourses of the disaster management field. The two discourses are the hazard paradigm and the vulnerability paradigm, as mentioned by Wisner (2016) and Gaillard & Mercer (2013). These two discourses have yielded two disaster management approaches, top-down and bottom-top, respectively.

However, the hazard paradigm is dominating the discourse as it relates disaster to hazard where it is seen as a natural occurrence. Malamud (2017); Wisner (2016) and Stefan *et al*. (2004) argues that in the hazard paradigm, people have less knowledge of hazards and risks which is why they are misinformed of their own environment and society. Hence, this paradigm sees disaster as natural, with a significant concentration on how to develop infrastructure and the engineering sector (e.g. building walls and dikes to protect against floods) (Coles & Quintero-Angel, 2018; Mercer, 2009). This discourse fully represents the top-bottom (in most cases called command and control) approach, where decisions are made centrally by stakeholders or the government. The discourse is focused and controlled by scientific knowledge (SK), and the local people are seen as passive actors in the disaster management approach as mentioned by Jahangiri *et al*. (2011). Based on these observations, it is clear that local communities are not involved in the top-down approaches. Instead, the local people's capacities should be addressed and identified for inclusive disaster risk management (Sim *et al*., 2021; Pearce & Mawson, 2003). Mercer (2009) and Mustofa *et al*. (2018) relate the failure of a top-down approach in disaster risk management as a result of the need for more vulnerable people involved in decision-making rather than the ideas or decisions pinned to the local people. Added to what has been criticized as the top-down approach Gougelet (2016) insist that it is a form of manipulation of vulnerable people as the concept is imposed on them without recognizing their local knowledge.

On the other hand, the vulnerability paradigm aims to understand that the vulnerability of people to disaster is influenced by the social, political, economic, and cultural lives of any given society (Wisner *et al*., 2013; Alexander, 2012). Unlike the hazard paradigm, the vulnerability paradigm upholds the importance of the local people's involvement in handling disaster risk management, thus making the paradigm a bottom-top approach where the local people and their knowledge are the centre of concentration rather than imposing an alien knowledge to them by the government as pointed out by Scolobig *et al*. (2015) . As the main approach to bottom-top is the community-based intervention approach, this thesis also looks into how indigenous knowledge can contribute to flood risk management in The Gambia. The thesis recognizes the local people to be the custodians of risk management in their communities (Rochmi, 2015; Orelli *et al*., 2020; Gaillard & Mercer, 2013) where there will be an effective mitigation approach to flood disaster in The Gambia. However, it is very vital to mention that there is no sovereign remedy to the flood risk management approach; thus, there is a need to have a balance of the bottom-top and top-bottom approach to be able to address the flood as a hazard (Scolobig *et al*., 2015).

2.3.0 Local Knowledge

By the initiation of Smith (2011), LK was known to have gained recognition in disaster management practice and research half a century ago. This came as a result of the quest for participatory development, in which everyone has a say in the development agenda. Participatory development came into existence as a result of the top-bottom approach losing its footing in development spheres, thus making the participatory agenda an answer to the bottom-top development agenda. This has promoted the local people and their knowledge, making them the main focus of development planning (Caviedes *et al*., 2024; Smith, 2011; Agrawal, 1995).

2.3.1 Indigenous knowledge

As enshrined in the English Oxford Dictionary, knowledge is information and skills that one gains through the process of education or generates through experience, and it includes both practical and theoretical comprehension of a given discipline or subject. Of recent, the scientific literature has been saturated with definitions of IK (Rivki *et al*., 2022; Raymond *et al*., 2010); looking at the situation, IK represents everything that people live in in a given society know about their vicinity

(Tweheyo *et al*., 2024). IK, having its genesis in a society or a specific location, can also be influenced by external or alien knowledge (Mercer & Howe, 2012; Kelman *et al*., 2012). Different terms for IK are commonly used in the literature. These include Indigenous knowledge (LK), local knowledge (LK), traditional knowledge (TK), folk knowledge, folk science, people's science, traditional ecological knowledge, and rural people's knowledge (Rochmi 2015; Shaw *et al*., 2010). Looking at these different terms Kelman *et al*. (2012) Said that the adaption of any term depends on the researcher's discipline or area of interest. However, in DRR, the term IK or LK is often used, especially in this research. This is based on the fact that the term provides a better understanding of any phenomena, representing the locality of the people and the characteristics of the study area (UNDP, 2011; Ben *et al*., 2009; Hiwasaki, 2007). On that note, this research conceptualizes that IK "encompasses the knowledge and practices that local people acquire over some time through the accumulation of experiences over generations, society-nature relationships, and community practices and institutions (Singh *et al*., 2018).

2.3.2 Local knowledge in disaster risk reduction

Living in hazardous areas requires adaptation, and people need to develop some IK to handle disasters (Smucker & Wisner, 2008). Local people have an in-depth knowledge of hazards in their community and their vulnerability (Tran, *et al*. 2009), how they use their IK in preparing for hazard, mitigation, response, and recovery from the disaster that came from that hazard (Mavhura *et al*., 2013). This has made IK be seen as a part of the local community's aspect of resilience (Caviedes *et al*., 2024; Trogrlic, 2020; Jon, 2019; López-Marrero & Tschakert, 2011). Due to the global threat from both anthropogenic and nonanthropogenic disasters, IK has recently become an area of concentration in disaster risk reduction research and policy making. As DRR is a discipline that has a lot of complex challenges, the need for the utilization and recognition of both IK and SK is of great importance (Weichselgartner & Pigeon, 2015). With all this significant recognition of IK in DRR, there is still a significant gap in the utilization of IK in DRR (Dube *et al.*, 2015).

Due to the inferiority of IK to the scientific society, its potential in DRR is yet to be fully harnessed (Coles & Quintero-Angel, 2018; Twigg, 2015) Due to the challenge of not having one universal definition of IK, there is yet to be an accepted classification of what makes IK with DRR. Many authors have mentioned different classifications. For example (Nguyen (2009) in a classification, views IK into two categories: belief system and technology; belief system has to do with culture, traditions, and social systems, and technology has to do with more physical features like local constructions. Tran *et al*. (2009) and Munasinghe (1992) explained IK through four broad categories of coping strategies: 1) material/economic (e.g. early warning, savings and credit schemes, additional labour, crop diversification), 2) organizational/social (e.g. community-based organizations, kinship networks), 3) culture (e.g. religious beliefs, risk perception), 4) technological (e.g. early warning, construction practices, land use mechanism). Above all the classifications, the most summarised and comprehensive one was done by Dekens (2007) in a literature review in Figure 2.

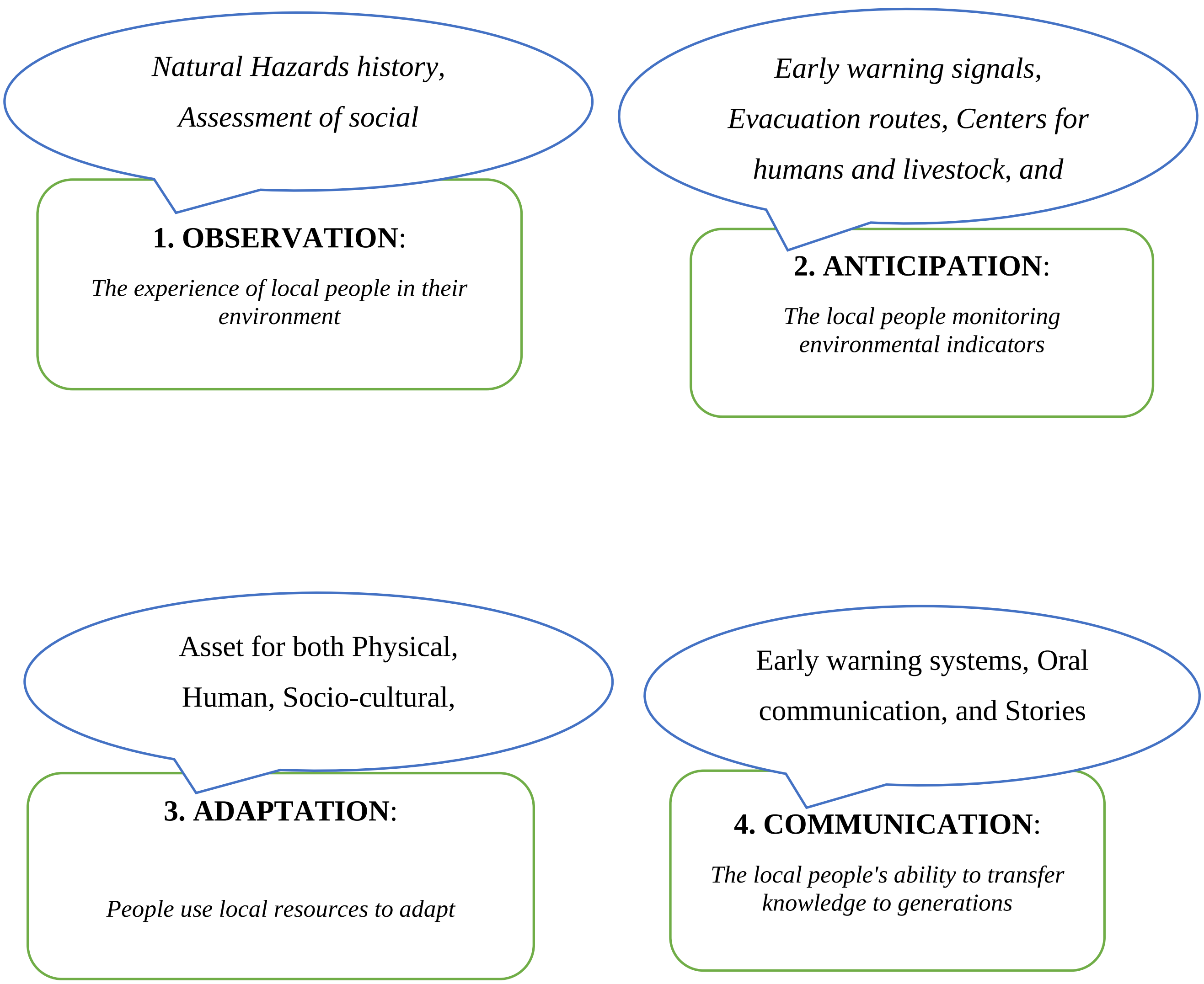

Figure 2: Four pillars of IK in DRR (adopted and modified from Dekens, 2007 and Trogrlic, 2020)

Dekens argues that IK involves observation, anticipation, adaptation, and communication. The research discovers that IK covers different knowledge types (e.g., technical, ecological, historical), beliefs, worldviews, and values, and its application has some effects on the sustainability of livelihood and community resilience building.

With all these differences in classifications, many scholars have seen IK in DRR as a multi-layered sphere that cuts across many spheres, thus incorporating many aspects of life. For example, IK is usually about communities' ranges from communities bearing knowledge of natural occurrences and their impacts to using Indigenous convenient materials for disaster-resilient construction, utilizing local indicators to predict floods and other disasters, depending on social networks and local organizations, and utilizing songs and compositions to relate warning messages and raise accepted risk awareness.

Recently, in DRR, there has been a strong emphasis on documenting IK in various forms. However, there is still a massive gap in the fulfilment of this quest of IK documentation, thus making IK in DRR be underscored and underutilized, making it somehow hard to clearly have a strong nexus between IK and DRR (Mercer, 2009; (Dekens, 2007). With this challenge, there are still some increasing studies reporting some collection of IK, e.g. (Islam *et al*., 2018; Ngwese *et al*., 2018; Lunga & Musarurwa, 2016; Santha *et al*., 2014; Fabiyi & Oloukoi, 2013; Irfanullah & Motaleb, 2011). Documenting IK is essential in the recognition and promotion of IK in DRR because it will portray that the local communities have an in-depth knowledge of disaster and different ways of adapting to the hazards. Hiwasaki *et al*. (2014) argue that documenting IK alone will not allow it to be utilized in DRR because it can only manifest IK with a shallow insight into the nature of the knowledge. The studies recommended that IK be fully utilized in DRR; it must be integrated into DRR policy. Klenk *et al*. (2017) and Hilhorst *et al*. (2015) also stated that documenting IK alone can be wrongly seen as a development agenda that can be easily packaged, handled, and transferred to different environmental contexts.

Many critiques on the focus of documenting good IK practices come with the cost of having a deep understanding of how the IK works (Klenk *et al*., 2017; Naess, 2013; Dekens, 2007; Briggs, 2005). Many studies presented a need for more understanding of IK as a process of knowledge production, yet Briggs (2005) argues that IK is positioned as a false dawn in development. Tran *et al*. (2009) emphases that due to globalization, there is a need for a paradigm shift from just mere documentation of IK into a deep understanding of the processes behind the production of IK. This must thoroughly understand how IK is created, gained, observed, transferred, stored, generated, refined, discussed, and used (Briggs *et al*., 2020; Dekens, 2007). In addition, having a better understanding of IK also has to do with considering how IK interacts with external institutions and knowledge. It also concerns the approaches towards development, which are viewed as limited in the current achieves (Naess, 2013; Carby, 2015). With the agreement made by Rivki *et al*. (2022), IK needs to be better understood, valued, and perceived by external DRR organizations like governments and non-governmental organization (NGO) officers. Knowing this, these organizations are kept in making IK understood and valued in formal DRR approaches; the lack of understanding of IK is a challenge to solve.

2.3.3. Characteristics of Local Knowledge

As IK is context-based and unique to a specific local community (Nguyen, 2009; Fernando, 2003) society or culture, it may not be fully applicable to an alien environment as it has to do with a local socio-economic context (Gusterson, 2013), and varies from one locality to another. In context, the local character of IK (by influence) usually gives power to the organizations and is relevant to development (Briggs, 2005). This can add input to the development projects in the communities. Hence, IK's custodian has a strong connection with the environment. IK is a solid basis for the local communities to make decisions as stated by Nyong *et al*. (2007), thus making it part of the local peoples' institutions (Fernando, 2003). Hence, IK is much more effective within the context in which it is created (cannot be generalized); it is also a challenge to make a general policy for other contexts out of specific IK (Kelman *et al*., 2012).

As IK is context-based, it is always created through experience over a long period of time and transferred to generations mainly through verbal rather than written communication (Huy Nguyen, 2009). Due to its experimental trial and error (Huy Nguyen, 2009), IK has a strong connection with learning the phenomena of the environment because the activities of the communities change over time (Agrawal, 1995). When the local communities are affected by a disaster, they try to adapt by understanding the trend of that disaster (Mitchell *et al*., 2022; Rose & Jayawickrama, 2016). Based on this, they make an effort to cope with their activities. The livelihood of the local people mainly influences IK as it is strictly connected to the everyday needs of the people (Dekens, 2007). On this note, IK is logic, not driven by formal principles of reasoning, making it induction rather than deduction as it is part of daily life (Mercer, 2012).

With all the misconceptions about IK, one thing is certain: IK is alterable and has the potential to evolve as the needs and experiences of the local people continue to change as a result of exposure to alien knowledge systems (Hilhorst *et al*., 2015; Gaillard & Mercer, 2013; Sillitoe, 1998). Unlike other knowledge systems, IK can evolve with the influence of foreign knowledge (Tengö *et al*., 2021). This type of influence can be related to “cross-fertilization” or “hybridization” with the scientific knowledge systems where it is intertwined and co-produced (Prakash, 2019; Hooli *et al*., 2016; Hiwasaki *et al*., 2014; Mercer *et al*., 2010; Briggs, 2005). Research carried out in India by Acharya & Prakash (2019) found that the local people make a connection between local signs commonly used and information from scientific forecasting. As stated by Mercer (2012), the local communities are mostly in haste to examine how the scientific knowledge is appropriate for their local use, thus making them pragmatic in their knowledge. On the other hand Briggs (2005) stated that the local people did not care about the origin of the foreign knowledge once it was capable of serving their needs and solving their challenges in the community. That is to say, the local people are more result-oriented.

Furthermore, IK is not analogous and is not a community peculiarity. Factors like gender, age, social status, and poverty levels have a great influence on different knowledge produced in a community, its usage, and access (Hilhorst *et al*., 2015; Dekens, 2007; Briggs, 2005; Sillitoe, 1998). DRR scientists have neglected this aspect of IK when working with communities. Based on this neglect, Turap *et al*. (2012) pointed out that IK should not be treated like a barrel. When needed, you can tap into it and forget about it later. It is essential to understand that within a community, there are different sets of people who possess different sets of knowledge. This is to say, people with different professions or livelihoods always have different types of knowledge about DRR (Wisner and Gaillard, 2009).

One important to know about IK is the fact that it can be influenced by the power attached to or related to it. This is to say that knowledge can be reserved for certain people who have specific power or influence in society. Research carried out by Cronin (2004) at Vanuatu in relation to IK on volcanic hazards indicated that women did not have access to early warning information on evacuation, thus making them rely on men for warning information. In a similar case Acharya and Prakash (2019) discovered that culture and society in many local communities don’t allow women to reach the local market where the flood early warning information is shared. In addition, in Nepal

Dekens (2007) discovered that IK can be monopolized by the local educated people in the society. Based on this, it is seen that the influence of the local elites can influence how IK is revealed and raised in relation to external knowledge (Dekens, 2007). Thus, local politics is not free from IK interference and influence; hence, it is power and dominance-related (Acharya & Prakash, 2019; Smith, 2011; Sillitoe, 2007; Briggs, 2005; Briggs & Sharp, 2004). It is obvious that IK is a social, economic, and political influence and shaped (Thompson, 1999). Based on this fact, IK is not totally free from social politics and cultural context. Funny enough, the approach of promoting IK makes it prone to lose its strength and local character (Briggs *et al*., 2013). Even so, the recent agenda for sustainable development has been recommending a generalization of IK (Smith, 2011). However, there is a need to keep in mind how IK, when modified, can lose its local context (Sillitoe, 1998). Hence, it is more effective with the geographical location in which it is developed (Dekens, 2007). The local and context nature of IK has limited it from being globalized and used in a different location (Hilhorst *et al*., 2015), although some researchers (Hiwasaki *et al*., 2014; Nguyen, 2009) hold the view that some components of IK (e.g. local construction practices, or technical component) can be globalized and used in different locations.

2.4.0 Integration between IK and SK

2.4.1 A need for the integration

Most of the studies dealing with the documentation of IK are mainly recommending ways of integrating IK and SK. As the call increases, the clarion call is to integrate IK and SK where effective DRR will be realized in the local communities (Acharya & Prakash, 2019; Bacud, 2018; Cadag & Gaillard, 2012; Mercer, 2009). This has become the focus of many DRR researchers. The main aim of integrating IK is as stated by Makondo & Thomas (2018) and Tengö *et al*. (2014) requested the integration amid global environmental drivers like climate change. On this note, communities that are affected by disasters frequently need a reason for integration (Hermans *et al*., 2022). IK integration is also needed in making SK and technologies much more fitting to the local contexts (Mercer *et al*., 2010), but it also helps in the understanding of SK; hence, IK gives a localized context of any DRR approaches (Kettle *et al*., 2014; Walshe & Nunn, 2012). When there is integration, the local communities' capacity is well mobilized for much resilience to disaster (Shaw, *et al*., 2009). In addition, integration can also be a way of relying on both scientific and local knowledge; as Mercer (2012) Stated, the limitation of one of the knowledge can be sorted out with the strength of the other, and vice versa.

SK has been seen as superior to IK in the modern DDR approach, thus gaining more attention for SK (Coles and Quintero-Angel, 2018). For this reason, much attention is given to showing the difference between SK and IK. Among the main differences is that IK is limited to a specific context, while SK is seen as global and universal (Mercer, 2012). SK is based on methodological and empirical approaches, while IK is seen as objective and intuitive (Sillitoe and Hardy, 2003); while IK has been developed from experiences, human-environment interaction, beliefs, and culture, SK has been generated by formalized processes (Raymond *et al*., 2010). IK is tacit (more of experiences and practices and not documented), while SK is explicit (well-experienced and documented) (Mercer, 2012).

However, with all these differences being highlighted in the literature, making attempts to emphasize or outline the differences between IK and SK will not be helpful, as it will continue to make restrictions and hindrances, thus shifting the attempt to make an understandable local-level resilience. As stated by Balay-As *et al*. (2018), it can also continue to maintain the power of SK over IK, where IK will be seen as a lesser knowledge in DRR compared to SK. This division, as stated by Agrawal (1995), is artificial and suggests attention to be made to understand the multiple domains of knowledge with different epistemologies. Raymond *et al*. (2010) refer to this division as "*epistemological pluralism*", as there are different ways of gaining knowledge, and what seems valued and accepted differs from other forms of knowledge. It is obvious that neither IK nor SK has developed in isolation, making them have a long history of interconnection (Tierney, 2015; Kniveton *et al*., 2015; Briggs, 2005). However, the division persists in DRR arenas (Balay-As *et al*., 2018), where IK is isolated (Hooli *et al*., 2016). There is concrete evidence that IK is facing marginalization, thus defending its potential value in the DRR arenas (Coles & Quintero-Angel, 2018). There is a need to deconstruct the division between IK and SK, and focus is to be given to how IK and SK can complement each other in making DRR more effective and proactive. By doing this, more emphasis can be put on how to understand the commentaries, which shows a step forward in the practical consideration of IK (Ludwig, 2016).

2. 5.0 Flooding and Indigenous Knowledge

2.5.1 Flooding and Indigenous Knowledge in The Gambia

Flooding, one of the critical consequences of climate change, poses significant challenges to the socio-economic structure of countries, particularly those in low-lying regions like The Gambia. Located along the Atlantic coast and intersected by the River Gambia, the country is almost entirely surrounded by Senegal. About 10% of The Gambia is covered by the Gambia River, and 20% consists of swampy areas and floodplains (NDC Partnership, 2022). Traditional communities in The Gambia, however, have long relied on indigenous knowledge to mitigate the impacts of flooding. This section explores the role of indigenous knowledge in addressing floods in The Gambia, with a focus on agricultural practices, water management, and traditional infrastructure.

2.5.2 Indigenous Agricultural Practices for Flood Adaptation

Agricultural production in Sub-Saharan Africa is highly vulnerable to the impacts of climate change, with approximately 96% of crop production relying on rainfed agriculture (Serdeczny *et al*., 2017). In The Gambia, where agriculture is the primary livelihood for most people, this vulnerability is compounded by rising food prices, currency depreciation, and food insecurity, all of which pose significant risks to the country's economic growth. Additionally, the sector is further threatened by the increasing risk of flooding. However, traditional agricultural knowledge has played a vital role in minimizing flood damage and improving resilience. For centuries, local farmers have developed flood-adaptive cropping techniques, such as staggered planting seasons, which help reduce the risk of total crop failure during floods. These practices are based on indigenous knowledge passed down through generations, including oral predictions of rainfall patterns and water levels (Sanneh *et al*., 2014).

One notable example is rice farming in The Gambia's Central River Region, where wetlands are prevalent and flooding is expected. During the wet season, excess rainfall causes the Gambia River to reach its flood stage, and the floodwaters spill onto the plains, submerging rice fields. Local farmers have adapted by cultivating flood-tolerant rice varieties capable of surviving in waterlogged conditions, reflecting their deep understanding of flood cycles and hydrology (M’koumfida *et al*., 2018; Carney, 1998)

In addition to relying on flood-resilient crops, farmers diversify their agricultural production and income streams to secure livelihoods. For example, they may grow multiple crops or even engage in migration as a strategy for managing risks associated with flooding. These adaptation strategies are largely incremental responses to changing climatic conditions, such as improving planting schedules, switching to more resilient seeds, and implementing preventive measures. However, such strategies, while beneficial in the short term, may lead to potential maladaptation in the long run due to cultural and ecological limitations (Filho *et al*., 2023).

One key challenge in upscaling these Indigenous agricultural practices is the cultural and geographical boundaries that define them. Indigenous knowledge is often specific to certain regions, making it difficult to generalize or apply these practices on a larger scale. Additionally, cultural norms can create a "lock-in" effect, where communities resist adopting new methods due to traditional values (Everard *et al*., 2021; Crate *et al*., 2017).

2.5.3 Traditional Water Management Systems

In regions prone to flooding, indigenous knowledge of water management plays a crucial role in mitigating the destructive impact of floods. Gambian communities have developed simple yet effective water management systems as local coping strategies (Mendy *et al*., 2024). These include the use of sandbags, natural barriers, small dams, bunds, dikes, and water channels to slow down or redirect the flow of floodwaters. These systems help divert excess water away from agricultural lands, thereby minimizing soil erosion and reducing the risk of crop destruction.

Village elders often lead the construction of dikes and embankments in rural areas, particularly in rice-growing regions. These structures act as safeguards against rising waters, protecting rice fields and other agricultural areas from flood damage (Bonell *et al*., 2022). The involvement of local leaders ensures that traditional knowledge is passed down and adapted to current conditions.

In urban areas, communities employ different water management strategies to cope with seasonal floods. Residents often contribute to a community fund managed by local associations to purchase materials like gravel to fortify flood-prone areas before the rainy season begins (Kavegue & Eguavoen, 2016). Local methods such as digging canals, using stones, and placing sandbags are also used to drain water away from homes and public spaces. Some families hire private garbage collectors to clean drainage canals, while others, who may not have the financial means, resort to burning waste or dumping it in vacant lots or uncompleted buildings. In extreme cases, families temporarily relocate to stay with friends or relatives during the rainy season.

Also, traditional water harvesting management is becoming popular. Gyampoh *et al*. (2009) highlighted that many communities are reviving the traditional practice of rainwater harvesting, using large barrels under roofs to collect water. This method was previously abandoned in favour of wells and boreholes, but as these water sources dry up, interest in rainwater collection has returned.

2.5.4 Traditional Building Techniques and Housing

In response to flood risks, indigenous Gambian building practices have evolved to incorporate flood-resilient techniques. In flood-prone areas, particularly in rural regions, houses are often constructed on elevated foundations, built on stilts, or situated on high ground to prevent damage from rising water. These elevated structures help protect homes from flooding, ensuring the living areas remain safe during heavy rainfall.

Traditional thatch roofs are designed with raised elevations to allow water to run off more efficiently, reducing the risk of collapse during heavy rains. Additionally, the design helps prevent floodwaters from entering homes. These housing techniques, while simple, reflect a deep understanding of local flood risks and demonstrate how indigenous knowledge can effectively reduce vulnerability in the built environment (Mendy *et al*., 2024).

By integrating these flood-adaptive features, indigenous building practices contribute to the resilience of communities, showcasing the importance of traditional knowledge in mitigating the effects of climate-related challenges.

2.5.5 Limitations and Challenges of Indigenous Knowledge

While indigenous knowledge provides essential tools for coping with flooding, its effectiveness is increasingly challenged by the intensifying effects of climate change (Gyampoh *et al*., 2009). The frequency and severity of modern floods, exacerbated by global warming, often surpass the capacity of traditional strategies, which were designed for natural environmental fluctuations. Indigenous methods, once well-suited to local conditions, now struggle to adapt to the increasing intensity of climate-related disasters (Karki *et al*., 2017). Gyampoh *et al*. (2009) note that traditional taboos, like restricting river access on certain days to protect water bodies, have declined due to modernization and the spread of Christianity, which views these practices as superstitions. The growing diversity of communities and the sensitive nature of religious beliefs have further diminished adherence to these traditional laws despite their potential usefulness in environmental conservation.

In The Gambia, traditional communicators known as "*kanyeleng*" have taken on important roles in climate change adaptation, helping create the social conditions necessary for citizens to hear and respond effectively to climate-related information (Sonko *et al*., 2020). However, broader concerns about the loss of traditional and religious values intersect with local understandings of climate change. As younger generations migrate to urban centres or adopt modern agricultural practices, traditional knowledge is at risk of being lost.

This has led to calls for integrating indigenous knowledge with modern scientific approaches to enhance resilience to climate change (Kinteh, 2003). The Gambia's National Development Plan aims to address this by focusing on sustainable environmental and natural resource management, enhanced climate action, and disaster risk reduction. Seven key program priorities have been identified: Agriculture, Forestry, and Other Land Use (AFOLU); sustainable waste management; coastal resilience and adaptation; hazardous chemicals and pesticide management; greening energy and transport sectors; integrated water resource management; and disaster risk reduction (IMF, 2023). The integration of the NDP with local traditional knowledge could provide the basis for the development of more effective strategies, as suggested by Gyampoh *et al*. (2009).

For coastal resilience, proposed interventions include nature-based solutions such as re-vegetation, technical advice to reduce coastal hazards, creating natural sinks by avoiding development in wetlands, formulating climate adaptation strategies, and finalizing the Integrated Coastal Zone Management (ICZM) Bill (Morris *et al.,* 2021).

2.6.0 Climate Change: From a Broader Region to the Context of The Gambia

Climate change is one of the most pressing environmental issues facing the world today. Its impacts are felt globally, but the severity and nature of these impacts vary by region. West Africa, including The Gambia, is particularly vulnerable due to its reliance on climate-sensitive sectors such as agriculture, fisheries, and forestry. This section explores the broader regional impacts of climate change, followed by a discussion of how these trends manifest specifically in The Gambia.

2.6.1 Regional Impacts of Climate Change in West Africa

West Africa is experiencing significant climatic changes, including rising temperatures, irregular rainfall patterns, and more frequent extreme weather events such as floods, droughts, and storms. Studies indicate that the region's average temperature has increased by 1.5°C over the past century (IPCC, 2022), with projections suggesting further warming in the coming decades (Niang *et al*., 2014). The average annual temperature is expected to rise above 22–28°C, with an increase of 1.4 to 2.5°C in Senegal and The Gambia by 2050, with the most significant warming occurring in the Sahel (USAID, 2018). Rainfall patterns have become increasingly unpredictable, with some areas facing prolonged dry seasons while others experience intensified rainfall, leading to flooding. These climatic shifts seriously affect food security, as West African agriculture is primarily rain-fed and highly vulnerable to droughts and floods (Falcon *et al*., 2008).

2.6.2 Sea-Level Rise and Coastal Erosion

West African countries with extensive coastlines, such as The Gambia, are highly vulnerable to rising sea levels and coastal erosion, both driven by global climate change. The Intergovernmental Panel on Climate Change (IPCC) has identified the West African coastline as one of the most at-risk regions in the world for sea-level rise. Approximately 90% of Senegal's industries are located within the Dakar coastal zones, similar to other coastal economies in countries like The Gambia, Ghana, Benin, Togo, Sierra Leone, and Nigeria (IPCC, 2023).

Coastal areas also serve as the region's food basket. Offshore and inshore waters, along with estuaries and lagoons, support artisanal and industrial fisheries, which account for over 75% of fishery landings in the region (IPCC, 2022). However, these areas face significant threats from rising sea levels, with projections indicating an increase of 17 to 43 cm in countries like Senegal and Nigeria. By the 2050s, sea-level rise could reach 1 meter, potentially inundating 18,000 km^2 of West Africa's coastline. This would severely affect croplands, key transport corridors, and livelihoods (USAID, 2018).

In The Gambia, coastal areas, including the capital, Banjul, are at significant risk of inundation due to rising sea levels. As a primarily low-lying country, a 1-meter rise in sea level could potentially submerge over 8% of its land area. This includes more than 61% of existing mangroves, 33% of swamps, and over 20% of lowland rice-growing areas(Camara, 2013; Jaiteh *et al*., 2010). Such inundation could flood more than 50% of Banjul, rendering it virtually uninhabitable. The towns of Barra, Jangjabureh, and Kuntaur, as well as the Port of Banjul, ferry terminals, and harbour landings along the River Gambia, would also be severely affected (Jaiteh *et al*., 2010); this not only threatens human settlements but also critical ecosystems like mangroves, which play a crucial role in protecting coastal areas from storms and erosion (Scholes *et al*., 2023).

The trend of rural-urban migration toward coastal areas, combined with encroachment on wetlands, has persisted over time (Kavegue & Eguavoen, 2016). Greater Banjul is among the most affected regions, with approximately 70% of all dump sites located in wetlands, drainage channels, gullies, depressions, and waterways. This poor waste management increases the vulnerability of these areas to flooding (Kavegue & Eguavoen, 2016). Coastal flooding, further exacerbated by rising sea levels, also poses a significant threat to fishing communities that rely on the coastline for their own (Bagagnan *et al*., 2019).

2.6.3 The Gambia: A Local Context of Climate Change

In The Gambia, climate change is already manifesting in all its four major ecosystem types: aquatic, coastal and marine; woodland; and urban ecosystems (Jaiteh *et al*., 2010) through shifting weather patterns, increased temperatures, and more frequent, intense floods affecting both urban and rural communities (Filho *et al*., 2023). The once-predictable rainy season has become erratic, resulting in both droughts and periods of intense rainfall in recent years. These climate impacts are compounded by the overuse of wood fuel, contributing to the destruction of forests and natural vegetation by up to 42% in 2001 (Jaiteh *et al*., 2010). This deforestation increases the risk of desertification, floods, erosion, wildfires, salt intrusion on farmlands, and insect infestations, all of which threaten food security and livelihoods (Permenkes, 2016).

In Baniko Ismaila, a village in The Gambia's Upper River Region, rice farming has been abandoned due to persistent flooding and saltwater intrusion (M’koumfida *et al*., 2018). This poses a serious threat to food security, as rice is a staple crop in the country. The 2021 Cadre Harmonies reported that about 10% of The Gambia's population, or 207,000 people, were food insecure. Key drivers of this insecurity include adverse weather events like floods, windstorms, and Fall Armyworm infestations, which have devastated crops in some areas (FAO/EU/CRAID, 2022). This unpredictability severely affects agricultural productivity (Akon-yamga *et al*., 2011), which is vital since 70% of the population relies on subsistence farming, with women contributing 40% of total agricultural output (Gambia NAPA, 2007). Agriculture employs nearly 46% of the labour force and provides livelihoods for 80% of the rural population.

As agricultural productivity declines due to climate change, many young people, 55% of whom are under the age of 25, migrate from rural areas to urban centres in search of employment (Czaika, 2020). With rural farming becoming increasingly unproductive, some youths risk dangerous journeys across the Sahara Desert and the Mediterranean Sea in hopes of reaching Europe (Jus, 2022). This migration highlights the growing social and economic challenges driven by climate change impacts in The Gambia.

2.6.4 Flooding and Livelihoods in The Gambia

Floods have been a significant natural hazard in The Gambia, constituting over 45% of such events between 1980 and 2020. Storms accounted for 22.7%, and droughts accounted for 13.6%, with heavy rainfall during the rainy season, poor drainage systems in urban areas, and inadequate flood control measures in rural regions being the primary causes (World Bank, 2019). The Gambia Bureau of Statistics has recorded flood events as far back as 1948, with notable instances in 1954, 1955, and 1956, and more recent events in 1988, 1994, 1999, 2002, 2003, 2004, 2005, and 2011 (Kavegue & Eguavoen, 2016; NDMA, 2013). In July 2010, severe flash flooding and thunderstorms displaced 8,495 people and affected 25,000 individuals, including 3,218 children under five and 174 pregnant women, resulting in one fatality (Campus, 2024).

In late July and early August 2022, The Gambia experienced severe flash floods with 276 mm of rainfall recorded over two days (30th and 31st July and 4th and 5th August) (NDC Partnership, 2022). This event led to 13 fatalities and affected 10,789 children aged 0-59 months, 1,143 pregnant women, and 2,618 breastfeeding women. Additionally, 458 water points were impacted. The floods also damaged access to clean water, destroyed latrines, and led to a household food crisis (Gendall, 2006). Health facilities reported increased cases of acute watery diarrhoea, malaria, and skin rashes.

The broader social and economic implications of these floods include heightened food insecurity and increased vulnerability among impoverished communities. Floods often displace people, damage property, and destroy crops. Inadequate infrastructure, low-quality shelters, and the limited resilience of the urban poor, particularly in Greater Banjul, exacerbate these impacts (Kavegue & Eguavoen, 2016).

2.6.5 Addressing Climate Change Impacts in The Gambia: A Multi-Faceted Approach

To mitigate the escalating impacts of climate change, particularly flooding, The Gambia needs a comprehensive strategy that integrates indigenous knowledge with modern science and technology (UNDRR, 2020a). Local communities employ various strategies to reduce disaster impacts and enhance disaster risk reduction (DRR). These include moving to safer areas, utilizing technology to provide advance alerts, placing sandbags around homes and beaches to prevent floodwater entry, adding sand to beaches to counteract erosion, heaping refuse at riverbanks and around homes to manage waste and prevent blockages, clearing riverbeds to improve water flow, cleaning and maintaining community drainage systems, and preventing sand winning activities to preserve coastal defences (Mattah *et al*., 2024).

Also, to adapt to changing weather patterns and improve agricultural resilience (FAO, 2016) includes using crops better suited to changing conditions, employing technology to optimize resource use, enforcing restrictions on agriculture and livestock grazing to reduce environmental stress, increasing vegetation to improve water retention, and enhancing capabilities for predicting and responding to climatic events. Despite these efforts, overall adaptation capacity in agriculture remains limited (Amuzu *et al*., 2018; IMF, 2023). To address increasing temperatures and changing conditions.

CHAPTER 2:

3.0 METHODOLOGY

3.1.1 Study design

This research employed qualitative and quantitative research designs (Colby, 2016). The Qualitative methods will seek to better understand the respondents' Indigenous knowledge in adapting to the impact of floods and ways to adapt to the current effect of floods. Quantitative modes of inquiry will also be employed (Jean-Baptiste *et al*., 2010, p. 48). In quantitative research, the design is more deterministic in methodological approaches with fixed basics, determining what strategy or design the research should implement.

The research was mixed-method research using a cross-sectional study. Data was collected both during the rainy season and dry season in The Gambia. This helped the researcher to have an in-depth understanding of what the rainy season and dry season look like in the study area. Three sampling communities were identified in each region, comprising 15 communities along the river Gambia covered in the research. The study sites were identified based on their proximity to the river Gambia.

3.1.2 Ethical consideration

Before embarking on this work, ethical clearance/approval was obtained from the Ministry of Higher Education, Research, Science & Technology, as the work is under the ministry's jurisdiction. Moreover, an informed written consent form or an oral explanation was obtained from each study participant, and only those who were voluntarily willing to participate in this study were interviewed, as they were assured of confidentiality.

3.1.3 Community visit

While waiting for the ethical clearance, the communities that were to be sampled in this study were visited prior to the commencement of the study in order to acclimatize and obtain consent from their “Alkalos” or heads of the communities. This activity was of great help to the authors, especially during the organization of FGD in many communities.

3.1.4 Recruitment and training of research assistants

Six (6) research assistants (3 females and three males) who had experience in research were recruited and trained to ensure that they were equipped with adequate knowledge of the research instruments and procedures. The training took a two-day workshop where they had a short assessment before they departed to the field. During the training, the research objectives were explained to them, as well as how to handle the confidential issues of the respondents.

3.2.0 Data and Methods – Objectives One

3.2.1 Research design and sampling

Qualitative research was more suitable as the research was conducted on ethnographic research by interviewing the community's members in a focus group discussion (FGD) (Sakurai & Munadi, 2018). This helped the researcher to interact fully with the informants and gain a better understanding through observation. The researcher employed an exploratory research design. The participants are known for experiencing hazardous floods and a seemingly local community.

The research focused on participants who were not below the age of 40 and who had stayed in that community for at least 8 years. This helped the informants provide local knowledge on adapting to the impact of floods in their vicinity.

3.2.2 Data collection, analysis and materials

Based on the nature of the research, multiple data collection methods and tools were used for data collection. The mixed approach is well-suited for providing critical insights into multiple viewpoints of the research problem (McKim, 2017). These included household surveys and focus group discussions (FGDS) to solicit information on the IK in flood risk management and the effects of flooding in local communities, coping mechanisms, and challenges faced by the local communities (Nalwanga *et al*., 2021).

The data was collected using Focus Group Discussion (FGD). The participants of the FGD were determined by age, period of stay in the area, and a general understanding of local knowledge in relation to flood hazards. FGD participants were selected considering gender equality. In each of the five regions, two focus groups were formed, one group consisting of females only and the other males. This helped to avoid biases and prevent a situation where men would dominate the discussion because of the traditional context of men having a more significant say in local settlements, although the reporting was done together as one community.

The participants in each group totalled 7. The selection of the community for the FGD was decided after the field visitation and during the administration of the questionnaires. This enables the researcher to have a field observation and assume which community is more local and has flood hazards. The total FGDs were up to 10 groups in five communities, making a total of 70 participants Table 2.

Table 2: Showing communities and the number of FGD participants

No.	**Name** of Community	**Region**	**No. of Participants**		**Cumulative Total No. of Participants**
			Male	Female	
1	Faraba Banta	WCR	7	7	14
2	Jenoi	LRR	7	7	28
3	Darsilameh	NBR	7	7	42
4	Kuntaur Wharf Town	CRR	7	7	56
5	Kaba Kamba	URR	7	7	70

Data was analyzed through thematic content analysis (TCA). Through this, the researcher identified, analyzed, and reported patterns in the data. With the use of qualitative software like MAXQDA and Taguette, the patterns were coded and classified into different themes to generate sub-themes. Figure 3 The themes were then described and compiled, and the report was written in the form of the result.

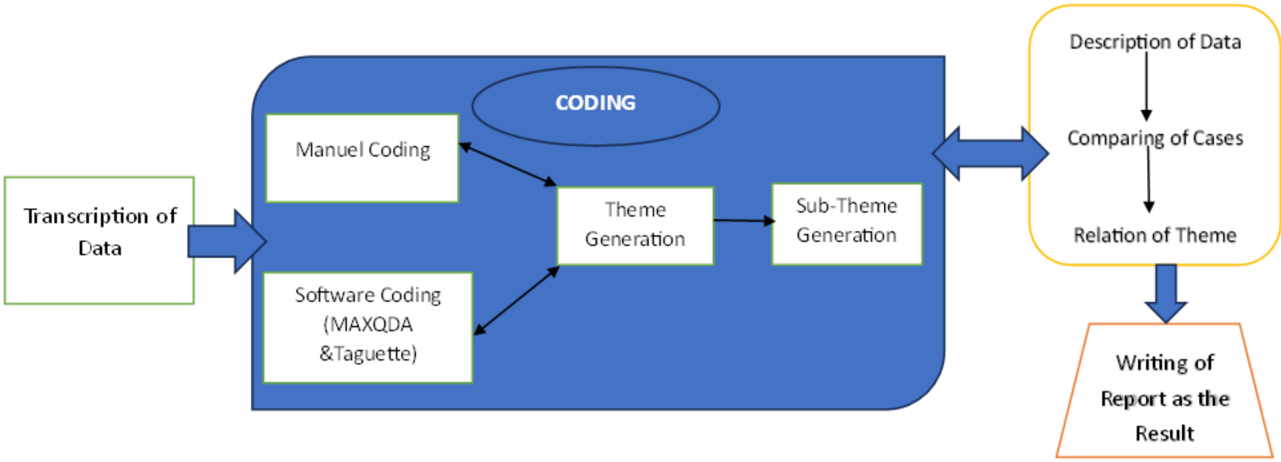

Figure 3: Representation of the method used in qualitative data analysis

3.3.0 Data and Methods – Objectives Two

For a flood risk map to be generated, The Gambia environment condition data of rainfall, slope, LULC, distance from the river, soil type, and elevation were used. These are the key factors for developing a flood risk analysis of a given study location.

3.3.1 Data sources and descriptions

The objective was met with the utilization of many data sources in the study area. In addition, soil type data, rainfall, slope, elevation, land use land cover (LULC), and distance from the river was obtained (Table 3).

Table 3: Showing data sources and description

Data type	Data	Resolution	Source
Elevation, Slope	The Shuttle Radar Topography Mission (SRTM)	30 m	USGS, 2024; (Farr *et al.*, 2007)
Rainfall	Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS)	5 km	CHC, 2024; (Funk *et al.*, 2015)
Soil type	FAO	30 m	Batjes 1997; (FAO, 2024)
Land use	Sentinel-2 Land Use	10 m	Esri., 2024; (Phiri *et al.*, 2020)

3.3.2 Software package used

All datasets were applied in the study area by utilizing all required data for proper analysis. Rasterization was performed to adjust the boundaries of the weighted overlay investigation under the GIS atmosphere. During the terrestrial study, the dimensional determinations, time filters, data corrections, and coordinate orders of the datasets were regulated to avoid incorrect datasets. These processes were carried out using Google Earth Engine (GEE) with the Java programming language. GEE can perform filtering and calculations based on cloud programming (Amani *et al*., 2020). After the datasets were processed, they were imported into ArcGIS Desktop, where geospatial analysis and visualization were conducted.

3.3.3 Data Analysis: Variables Used for Analysing Flood Risk

Soil types

Soil type analysis allows for determining the critical determinants in delimiting flood-prone areas. Soil type significantly impacts the rate of rainfall water infiltration and the soil water holding capacity within a given location. According to Gashaw & Legesse (2011), infiltration has a significant effect on the surface drainage produced by the precipitation process. In a suitable way, clay soil infiltrates at a much lower rate than sandy soil (Hagos *et al*., 2022).

Slope

The STRM DEM was used to generate the research area's slope on a degree basis. Hagos *et al*. (2022) divided the slope into five categories: very high, high, moderate, low, and very low: 0°–2°, 2.1°–5°, 5.1°–15°, 15.1°–35°, and > 35.1°. Water can flow down steep slopes to rivers more quickly than it can through overland flows, which tends to decrease the quantity of water infiltration into the ground. Steep slopes additionally result in increased soil throughflow. The length of the slope influences both the likelihood of flooding and the actual occurrence of floods since water builds up gradually as it moves along the slope from high to low, and floods usually occur in the lower area.

Land-use and land-cover (LULC)

Because it can speed up or slow down surface flow, LULC can contributes significantly to flooding in one way or the other. The Sentinel-2 – 2 (Kumari & Karthikeyan, 2023) of 2022 LULC types in the study area were categorized using maximum likelihood supervised classification. The Gambia's LULC types were thus divided into water, trees, flood vegetation, crops, built area, bare ground, and rangeland. According to Kundzewicz *et al*. (2017) and Yin *et al*. (2023), land use, population density, and population expansion in the basin or community are all factors that contribute to floods.

Distance from the river

The research area's flood risks were classified according to their level of severity and proximity to a water source. Floods result from surface water discharge due to the volume of water generated by rainfall, streams, tributaries, and released subsurface water. According to Yin *et al*. (2023); Ullah & Zhang (2020), this occurrence suggests that the research region closest to the water body is more susceptible to flooding than the areas that are far from the water body.

Rainfall

The status and seasonality of rainfall are also key determinants for evaluating the impact of flood risks on Gambia. Heavy rainfall conditions can result in the occurrence of higher flooding risks on the surface of the study area and vice versa. In addition, rainfall also increases the volume of the water in the water body and increases the severity of surface water flooding in the study area (Tesfay, 2018; Assefa *et al*., 2018), thus causing the overflow of rice fields, especially in communities that are well-known for rice production.

Elevation

Elevation shows the location of the study area as above or below sea level. It can determine the speed of runoff and the status of flood accumulation in the study area. An area with lower elevation is characterized by high flood risks and higher flood accumulation, while areas with high elevation are seen to have low flood risk and flood acceleration.

3.3.4 Parameters rating scale for flood risk assessment:

The scale difference in the study area may show the various flood risks in The Gambia (Table 4). Assessment of the aforementioned difference allows stakeholders and land managers to label flood risk-like fields and provide instructions for future preservation, thus building the resilience of local communities.

3.3.5 Scale Analytical Process:

To obtain a proper analytical process of the scale, we utilized parameters such as soil type, distance from the river, slope, elevation, rainfall, and LULC to allocate and identify flood-prone areas within the study area. The multi-criteria decision analysis (MCDA) tool and analytical hierarchy process (AHP) method were used to calculate a weight value for each of the parameters used during the study (Table 4) (Saaty, 2002; Saaty, 2008).

Table 4: Showing Scaled and weighted flood risk and hazard factors

No.	Factor	Weight	Subfactor	Scale Level
1	Elevation (m)	0.2	0-10	5 (Very High)
			10-20	4 (High)
			20-30	3 (Moderate)
			30-40	2 (Low)
			40-60	1 (Very Low)
2	Slope	0.15	<2	1 (Very Low)
			2-5	2 (Low)
			5-8	3 (Moderate)
			8-10	4 (High)
			≥10	5 (Very High)
3.	LULC	0.2	Trees	4 (High)
			Flood vegetation	5 (Very High)
			Crops	3 (Moderate)
			Built Area	2 (Low)
			Bare Ground	1 (Very Low)
			Rangeland	1 (Very Low)
4.	Soil type	0.1	Water	5 (Very High)
			Thionic Fluvisols	5 (Very High)
			Gleyic Luvisols	4 (High)
			Eutric Regosols	3 (Moderate)
			Eutric Fluvisols	3 (Moderate)
			Ferric Luvisols	2 (Low)
			Distric Nitosols	1 (Very Low)
5.	Rainfall	0.2	<500	1 (Very Low)
			500-800	2 (Low)
			800-100	3 (Moderate)
			1000-1200	4 (High)
			≥1200	5 (Very High)
6.	Distance from river	0.2	<10	5 (Very High)
			10-20	4 (High)
			20-40	3 (Moderate)
			40-60	2 (Low)
			≥ 60	1 (Very Low)

3.3.6 Flood Risk Analysis Approach:

Rasterization was performed for appropriate parameter-weighted overlay analysis under GIS environments. The weighted value of each parameter was calculated using the artificial hierarchy process (AHP) method for pairwise comparison based on their percentage of influence in determining the status of flood risk in the study area. In order to produce a flood risk map of The Gambia, we made use of all criteria maps of all the parameters used in this study. After that, we overlaid those criteria maps where we used the suitability index to determine the flood-prone areas of The Gambia. According to Merga *et al.* (2023); Debesa *et al.* (2020), flood risk in the was determined as follows:

$$\mathbf{SI = \sum Wi \times Xi}$$

Meaning SI is the suitability index, Σ is the total summation, Wi refers to the weight of factor i, and Xi is the normalized criteria of the factors.

For this reason, this study adopted a framework of Merga *et al.* (2023; Debesa *et al.* (2020) as represented in Figure 4. In order to arrive at the final flood risk map, this study also adapted the framework of Sendai framework for disaster risk reduction (UNDRR, 2015b), where the framework focuses on the three dimensions of measuring disaster risk (DR) exposure to hazards, vulnerability, and Hazard's characteristics (Hazard, Exposure and Vulnerability). As indicated in Figure 4, the Hazard in this study is precipitation (rainfall). Exposure is regarded as river, elevation, and slope, and vulnerability is referred to as Population, soil type and soil cover.

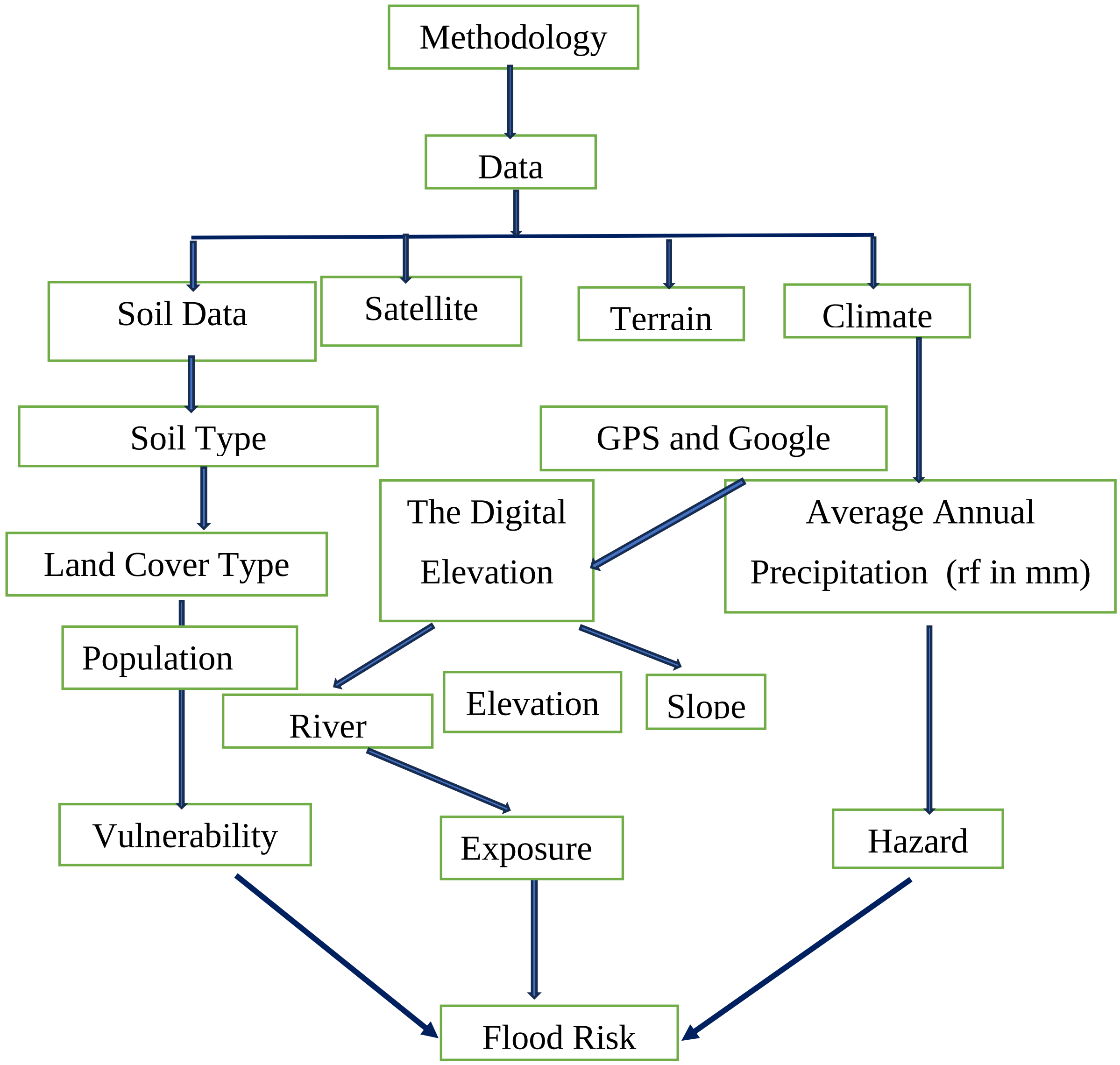

Figure 4: A framework showing how the flood risk map was generated. Adapted and modified after (Merga et al., 2023); (UNISDR, 2017)

3.3.7 A Community-Based Flood Impact Assessment and Buffer Mapping in The Gambia: A Regional Perspective

This subsection tried mapping flood-prone areas in the various regions of The Gambia. It also highlights the use of buffer zones for flood risk mitigation. This data was collected in the following communities (Table 5) across the 7 regions in The Gambia. The data collection of the area covered by flood water in an unprecedented rainfall in The Gambia was done from July 24th to November 30th, 2022. Although the severe rainfall starts from July 30th to August 31st, there was a need to wait for the level of the water to lower down to have a measurement of the two pegs fixed before the flood and after the flood respectively. This was done as an evident to test and validate the local people making approximation of the mark of level of water on structures (Figure 6) and tress (Figure 9).

This helps the researcher to feel the first-hand impact of the flood in various communities in Table 5. Note this data collated was meant to fulfill a part of the objective of this thesis in filling the gap of areas that are prone or at risk of flooding in The Gambia knowing that the country faces seasonal flooding and not for a detailed country-wide assessment. Based on this limitation, there is a need for a detailed collection of this type of data of all communities along the river Gambia to highlight more accurate areas that are flooded during flooding events. In producing a buffer flood map for each region, the average disaster covered by water from July to November 2022 for each region was used as a buffer around the river and water bodies to indicate areas that are "NO-BUILD" places due to the extreme flood events.

Table 5: Flood-affected Areas and Average Distance Covered by Floodwaters in The Gambia (July to November 2022).

REGION	LGA	NAME OF THE COMMUNITY	DISTANCE PER COMMUNITY (M)	AVERAGE DISTANCE COVERED PER REGION (M)
Banjul	Banjul	Banjul North	89	92.5
		Banjul South	96	
Kanifing	Kanifing	Tarlingding Faroto	146	160.5
		Ebo-town	175	
WCR	Brikama	Faraba Banta	183	172
		Bintang	161	
LRR	Mansakonko	Pakaliba	203	172.5
		Jenio	142	
NBR	Kerewan	Darsilameh	171	166
		Juffure	161	
CRR	Kuntaur (CRR North)	Kuntaur Wharf Town	237	164.5
	Janjanbureh (CRR South)	Wali-Kunda	92	
URR	Basse	Basse Badala	71	75.5
		Kaba-Kamba-South	80	

Note: the communities listed in this table represents the all the 7 Regions with 2 communities from each region.

3.4.0 Data and Methods for Questionnaires on Objectives 3 and 4.

3.4.1 Study design

The objectives of this research section were designed using a community-based cross-sectional research approach (Zacharia, 2022). The research was conducted using questionnaires, which were helpful in determining the level of flood impact and climate variation's effect on the local communities. Before data collection, these questionnaires were pretested for reliability and validity (Liu & Miao, 2021). A semi-structured interviewer-administered questionnaire was used (Phungula, 2021).

Simi-structured questionnaires were used for the household surveys to collect data from 422 households in selected communities throughout the country through a simple random sampling method (Abbas & Routray, 2014). The questionnaires were used to collect data on the impact of flood and climate variation on the local people in the study area.

3.4.2 Study Population/ Sample Size Determination

The sample size of the study population for the research was unknown when the sample size was estimated. Thus, 50% was used as the recommended proportion for the unknown population. The required sample size of 422 respondents will be calculated using Cochran's formula as follows:

$$n_0 = \frac{Z^2pq}{e^2}$$

Where;

n = Total Sample Size (n = 384)

p = Proportions of the samples from the population (50% will be used because it was unknown)

Z_α = Confidence interval (95% CI = 1.96)

e = Precision at the 95% CI (5% or 0.05)

NB: After adding a 10% non-response rate, 422 respondents were interviewed.

3.4.3 Sampling techniques

A purposive sampling approach was used to select communities in both regions (Ntajal *et al*., 2017). A simple random sampling technique (Hu *et al*., 2021) was used to collect the data from respondents in selected communities.

3.4.4 Inclusion and exclusion criteria

Both women and men aged 30 and above of each household head were allowed to participate in the research. The only household within the study area was captured. Any person who has stayed in the research area for a minimum of 1 year was excluded from the research because he/she may not have experienced last year's rainy season. **Noted**: this criterion is different from the above mentioned (Page 51) as it only covers the questionnaire survey and not the qualitative interview in IK.

3.4.5 The data processing and analysis

Statistical software like SPSS, DataTab, and R software was used to analyze the data. The questionnaires were checked for completeness, coded, and entered into excel for analysis. Descriptive statistics (Mean and standard deviation) were used to summarize the data. Tables and bar charts were also used to summarize the data.

Principal component analysis (PCA) was used. Using PCA, the standardized z-score was used to disentangle the overall assigned scores to poor, fair, and reasonable. Multiple correspondence analyses were used to identify the factors and to show the variation between regions.

3.5: Study Area

The Gambia is a small country that occupies the two banks of the Gambia River, which are north and south of the river (Gambia & Diagnostic, 2020). It lies between latitudes 13 and 14°N, and longitudes 13 and 17°W. According to the 2013 Population and Housing Census, The Gambia has a population of 1,882,450 with a density of 176 persons per km² (GBoS, 2013). The Gambia has a long dry season from October to early June characterized by dust-laden winds blowing from the Sahara Desert. The short rainy season spans from mid-June to early October, during which rainfall ranges from 850 mm to 1,200 mm (Jaiteh *et al*., 2010). The southwest monsoon winds, combined with continental heat, give rise to thunderstorms often accompanied by strong winds, heavy rain, and severe lightning (Camara, 2013). The peak of rainfall occurs in August.

The Gambia River is a river in West Africa that is 700 miles (1,120km) long and has its source from the Fouta Djallon highland in the Republic of Guinea. The river flows westward to the Atlantic Ocean, dividing the country into north and south. The river has major tributaries like Sandougou and the Sofianiama. The river is one of the navigable rivers in West Africa. From Fouta Djallon, its source, the river winds its course to its mouth, thus creating several islands. The two biggest are Elephant Island and MacCarthy Island. The river has many creeks, called "Bolons", and the largest of those in Bintang Bolon south of the river. The width of the Gambia River varies along its course (Britannica, 2017). The Gambia is located on the flood plain of the Gambia River and is flanked by savannah and low hills, with the highest elevation being 53 meters above sea level (Engel, 2014). It has 80 km of open ocean coast and approximately 200 km of sheltered coast within the tidal reaches of the River Gambia (Gibba *et al*., 2020).

This research covered the whole country; hence, the focus of the assessment was based on the risk of flooding. The five regions (West Coast Region (WCR), North Bank Region (NBR), Lower River Region (LRR), Central River Region (CRR), and Upper River Region (URR) and the two administrative regions (Kanifing Municipal (KM) and Banjul (Bjl)) were covered in the assessment of vulnerability. In the FGD, the five regions were also covered, leaving the other two administrative regions (Kanifing and Banjul). The objective is to know the indigenous knowledge of the people living in the rural, remote communities along the river Gambia.

Settlements along the River Gambia, which are much closer to the river, motivated the selection of this research area. The River Gambia divides the country into north and south banks and gets its source from Futa Djallon Highland (Kroot & Gokee, 2019). The River Gambia shared its source with three countries: Guinea Bissau, Guinea, and Senegal (Brief, 2013). Communities like Basse Wharf Town- South of URR, Kaba-Kamba-South of URR, Basse Badala -URR North, Kuntaur Wharf Town- CRR North, Wali-Kunda-CRR South, Sapur- CRR South, Juffure information center-NBR, Darsilameh-NBR, Kerewan-NBR, Kemoto-LRR, Pakaliba-LRR, Jenoi-LRR, Bintang-WCR, Faraba Banta-WCR, Brefet Bolon, will be the communities to be covered during the survey data collection and two from each region was used to do the buffer data analysis as in Table 5. These communities are selected based on their proximity to the river and their history of flooding events.

Table 6: Households and Average Household Size (2003 and 2013) by LGA (GBoS, 2013)

LGA	**Region**	**Population**		**No. of Households**		**Calculated sample size**
YEAR		**2003**	**2013**	**2003**	**2013**	
Banjul	Banjul	35,061	31,301	6,853	6,657	12
Kanifing	Kanifing	322,735	382,096	49,016	67,119	123
Brikama	WCR	389,594	699,704	45,139	87,864	162
Mansakonko	LRR	72,167	82,361	8,432	8,919	16
Kerewan	NBR	172,835	221,054	18,242	22,407	41
Kuntaur	CRR	78,491	99,108	7,104	9,321	18
Janjanbureh	CRR	107,212	126,910	10,115	11,238	21
Basse	URR	182,586	239,916	12,593	15,975	29
Total		1,360,681	1,882,450	157,494	**229,500**	**422**

According to The Gambia Bureau of Statistics (GBoS), in the 2013 Population and Housing Census Preliminary Result, the total number of households in the country is 229,500 (GBoS, 2013) as presented in Table 6. Kuntaur is located in the Central River Region, in the Niani District, North Bank of The Gambia River. It is about 3 kilometres south of Wassu and 13 kilometres north of Janjanbureh in the same region. The area has two primary sources of water supply: surface water and underground water. Underground water is mainly used for drinking, and surface water, which includes river streams, is used for other activities such as irrigation(Yahaya, 2008). Basse Santa Su is a town and port area in the eastern part of The Gambia. And on the south bank of the Gambia River (Britannica, 2009).

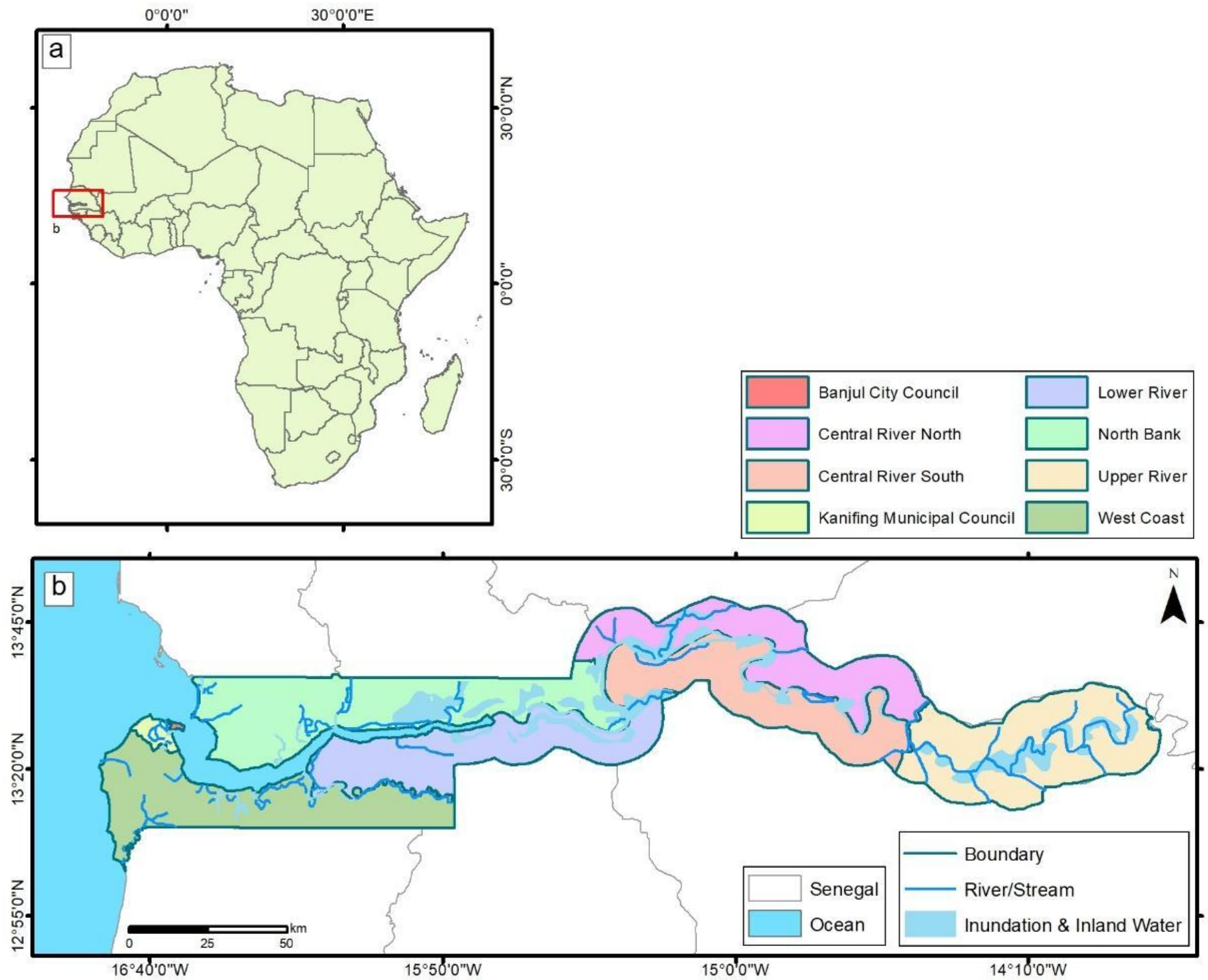

Figure 5: Map of the study area (a) insert map of Africa (b) area of interest

CHAPTER 3:

RESULTS

SECTION 1: Objective 1: To examine Indigenous knowledge of flood hazards in The Gambia.

4.0 Indigenous local knowledge for flood risk management:

This section unpacks different dimensions of IK for flood risk management commonly used among local communities along The Gambia River. Findings presented herein predominantly contribute to the third study objective, which is to analyse Indigenous coping strategies for flood hazards in The Gambia, thus contributing to the literature's calls to document IK. Furthermore, the results partly reveal findings related to the second study objective, which is concerned with assessing the flood impacts on the communities along the Gambia River.

This section covers the identification of IK and presents the IK in three stages (pre-flood disaster, during flood disaster, and post-flood disaster).

4.1.1 Local People's Knowledge of Flood Hazard

In various case study communities, individuals typically exhibited a comprehensive awareness of the flood risks present in their respective communities. This encompassed recognising various flood types and attributes, discussing the underlying causes of flooding, and providing detailed accounts of perceived alterations in flood occurrences over time.

4.1.2 Types of flooding and flood characteristics

As a consequence of residing in flood-prone regions and experiencing recurrent flooding, communities within the case study areas have developed an understanding of various flooding types and their characteristics, including frequency, duration, and spatial behaviour. Generally, communities distinguish between two primary types of flooding: fluvial flooding originating from the river Gambia and flash flooding triggered by heavy rainfall, with both occurring annually, according to the local people. Flash flooding typically inflicts significant damage during intense rain spells, particularly affecting those residing in proximity to the river or low-lying areas.

Additionally, participants highlighted the exacerbation of flooding when river tributaries are unable to discharge into the main channel.

Furthermore, local people were able to draw distinctions between “normal annual flooding”, often viewed as beneficial for agriculture due to residual moisture in fields, and “extreme annual flooding events”, which participants recalled as having particularly severe impacts on their communities and livelihood.

‘’*Yes, normal flooding is good because it watered our rice fields until the harvest time, but floods like the year 2022 and 2023 have seriously affected our farmland and destroyed houses and roads because it is still in our memories” (FDG Daselemeh)*

This data holds significant potential for constructing historical profiles of flood occurrences within local communities in the Gambia. Although NGOs in The Gambia document some flood events, the existing flood database faces challenges, particularly regarding the level of detail provided. Consequently, information gathered directly from local residents can substantially enhance the specificity of flood management planning activities within villages.

The majority of the communities experience flooding predominantly during the rainy season, spanning from August to early October.

‘’We suffer from floods, especially in the month of August when it used to rain for the whole day to the month of early September or early October”. (FGD Faraba Banta, Jenio, and Kaba Kamba)

Local communities, most of the time, are caught unaware of this type of flooding, leading to the perception that floods are unpredictable. Local people highlighted that this flood impact happened in the night increasing vulnerability to hazards like collapsed houses and where timely evacuations are hindered. Notably, participants recalled an August 2022 flash flood event, indicating its significance as a recent experience they can still remember.

Communities often find themselves ill-prepared for this type of flooding, leading to a perception of unpredictability. Particularly concerning is the occurrence of nighttime flash floods, increasing vulnerability to hazards like collapsed houses and hindering timely evacuations. Notably, participants recalled a January 2015 flash flood event from the Ruo River, indicating its significance as a recent experience.

In addition to discussing flood heights and durations, local people in the communities provided valuable insights into flood dynamics, aiding flood risk management efforts, especially in data scarce regions like The Gambia. They differentiated between the height of annual and extreme floods, often using local ways of reference points to water layer marks on bricks or trees (Figure6). Extreme fluvial floods were reported to linger for months, contrasting with the shorter duration of annual flash floods that take a few days or weeks.

Figure 6: A man in Kuntaur Wharf Town (CRR North) indicated water levels on wall bricks during flooding in 2022.

According to local people's reports, the duration of floods in rural areas varies depending on the severity of the flooding and the type of flood (fluvial or flash floods). However, communities note that floods can occur consecutively, making it difficult to predict their return to their houses and farmland accurately.

“We may not be able to tell when the water will completely go down, as rain may come again when we see water going down after few days of serious flooding” (FDG Kaba Kamba)

Participants exhibited a deep understanding of flood dynamics in their areas, including how water enters and spreads within their localities. They can anticipate flood severity based on rainfall intensity and duration. For instance, short bursts of rain indicate flooding in fields and roads, whereas prolonged rainfall warns of potential impacts on housing, leading to flooding inside the rooms.

“*We know that when it falls for the whole day, we will have flooding in our farms, but when it goes on for 2 days, we prepare ourselves because our houses can be flooded" (FGD: Kuntaur Wharf Town)*

Additionally, participants are well aware of the differing levels of exposure and vulnerability across their communities and regions. They repeatedly emphasised that households in low-lying areas are most severely affected. Moreover, communities recognise the heightened risk faced by areas with lower topography.

"Our village faces flood, but compounds that are very close to the river or around the swamps are more affected when we experience flood" (FGD: Faraba Banta and Darsilameh)

Understanding the spatial distribution of floodwaters enables communities to identify safe evacuation routes during emergencies. For example, participants in Kaba Kamba-South of URR specific road as the boundary of the most extreme floods they have experienced. However, their knowledge is limited to their past experiences, which may pose challenges when facing floods of greater magnitude.

4.1.3 The causes of flood

Almost all participants highlighted various factors and processes perceived as contributors to flooding in their localities (Table 7), demonstrating a comprehensive understanding of the underlying causes. of flash floods. These factors encompassed both immediate triggers of flooding, such as rainfall, and broader conditions exacerbating the phenomenon, such as environmental degradation, poor housing, and population growth. Environmental degradation emerged as the most significant process, operating both locally (e.g., land clearance for agriculture and building of houses) and across broader spatial scales (e.g., deforestation in upland areas). Participants noted that deforestation reflects a more significant issue in The Gambia, where poverty underscores vulnerability. As articulated by a respondent in an FDG in Dasilameh:

"Because of the economic condition in The Gambia, we men are cutting down trees as we rely on tree cutting for income generation."

Another commonly cited cause of flooding was the siltation of riverbeds, which reduces the river's capacity to carry water effectively. Additionally, various other factors related to hazard characteristics, such as rainfall intensity and duration, dynamics of river networks, and backwater flow, were identified as contributing to flooding. Factors related to exposure, such as geographical location and vulnerability, as well as population growth and external interventions, were also acknowledged as playing a role. It's worth noting that only a few elderly participants attributed floods to supernatural causes, such as Acts of God, indicating that such explanations were rare.

Table 7: The Causes of flooding as identified by research participants/Informants

No:	Causes	Explanation	Recommendation From the Participants
1	Heavy Rainfall	Local communities experience intense or prolonged rainfall, leading to increased runoff.	To improve community drainage systems, construct small-scale flood control structures, and promote rainwater harvesting.
2	Poor Drainage Systems	Inadequate or poorly maintained drainage systems result in water accumulation and flooding.	Mobilise community efforts to clean and maintain existing drainage channels and advocate for government support in upgrading drainage infrastructure.
3	Deforestation and Soil Erosion	Deforestation reduces vegetation cover, causing soil erosion and increased runoff into the river Gambia.	Organise tree planting campaigns, raise awareness about the importance of forests and implement soil conservation practices at the local level.
4	Riverbank Erosion	Erosion along riverbanks diminishes their capacity to contain water, leading to overflow.	Engage communities in riverbank stabilisation projects using locally appropriate techniques such as planting mangroves or constructing check dams.
5	Climate Change	Changes in climate patterns result in more frequent and intense rainfall events.	Strengthen community resilience through diversified livelihoods, promote climate-smart agriculture, and establish early warning systems at the local level.
6	Poor Agricultural Practices	Improper land management practices such as overgrazing and monoculture increase soil erosion.	Provide training on sustainable farming methods, support crop diversification, and implement soil conservation techniques tailored to local farming practices.
7	Population growth	Because of population growth, many people have been forced to build houses in flood-prone areas.	The local government should not allocate lands with a high level of flood risk.
8	Topography	Houses or farmland in lowland areas are more prone to flood	Before building or planting crops on land, one needs to check the topography of that land first.

Note: Table 7 presents key causes of flooding in local communities in The Gambia, along with explanations and recommendations from participants.

4.1.4 IK in Pre flooding

IK used in pre-flooding was seen to be widely used in the research area. Pre-flooding IK can be grouped into three main groups;

i. Local early warning indicators of the local communities
ii. Early action to flood
iii. Mechanism of flood risk reduction

I. Local early warning indicators of the local communities

What local people view as early warning indicators is seen as their indigenous knowledge. Table 8 shows some relevant IK indicators of early warning collected from the research area.

Table 8: Identified IK on Early Warning In dicators in The Gambia

GROUP OF IK	SIGNS	TIME IT HAPPENS	EXPLANATION
Meteorological	Increase of rainfall	July to Late August	High likelihood of flooding to occur
	Rainfall duration	Early June to Late October	The more the rainfall, the more flooding is expected
	Rise in temperature	March to October	the higher the temperature, the more the rainfall, and vice versa
Riverine	Rise of water level	July - September	To determine the level of rainfall in a given rainy season.
	Colour of water change	March to May	A sign of rainfall starting soon, making the people prepare
	The sound of water increase	April	A sign of rainfall starting soon, making the people prepare
Ecological	**Fauna**		
	Hippos and Crocodiles moving to the village fields	March - April	A sign of scarcity of food and water, thus an indication that rains to come soon
	Birds making a particular sound (e.g. "Sama yato seta")	April -May	During this period, people are alert to rainfall and have started preparing.
	Flora		
	The Baobab (*Adansonia digitata* L.) tree produces many leaves.	May onwards	It is a sign of the nearness of rainfall.
	Many bamboo (*Adansonia digitata* L.)trees growing near the river	May onwards	It is a sign of the nearness of rainfall
	The mango (*Mangifera indica* L.) tree produces many fruits.	April to May	It is a sign of the nearness of heavy rainfall in that year.
	Acacia Albida Del. is forming much leave.	February - May	This shows that there will be a heavy rainy season that can trigger floods.
	The tamarind (Tamarindus indica L.) tree forms many flowers.	May to Jully	This is an indication that there will be heavy rainfall that year, so people anticipate a flood
Celestial	Moon halo, or Moon dog	not specified	When the ring (halo) around the mood is seen, the local people believe that there will be heavy rainfall.
	Full moon	not specified	When there is a full moon, people suspect that destructive rainfall will come any moment after.
	Appearance of Orion Star	not specified	"When we see the bright, we believe that in a few days, there will be rainfall so that we will prepare for any emergency, such as a flood."

Note: Table 8 outlines various local indicators used by communities in The Gambia to predict rainfall patterns and potential flooding.

Signs used by the local people to foretell flooding originated from the people's interaction with their environment, resulting from their daily experience and livelihood (Table 8). Farmers report the phenomenon of animals of trees as their early warning indicators, while fishermen relate to riverine behaviour as an indicator of flooding.

II. Early Action to Flood:

IK sharing and transferring from one generation to the other is very important; it will only be effective once there is early action. In this research, early action is viewed as a mechanism by local community members to reduce the impact of flooding after strictly following their local early warning indicator. Participants in all the communities believed that those people who act proactively are less affected by floods and vice versa.

"*Yes, many people are less affected by flood because they act early and prepare for the rains and flood…..".* Since the transforming IK can lead to disaster preparedness and reduce the effect of disaster, it is vital to look at the type of early warning actions taken by the local people in The Gambia (Table 9). This is shown below:

Table 9: The Local People Early Warning found during the research

Groups of Early Warning Actions	**Early Warning Actions**	**Explanations**
Houses adjustment	i. A cement layer made from mood blocks is applied to the walls of the houses. ii. Temporary dikes or waterway buildings in the community. iii. Using grass to thatch the houses. iv. Reinforcing the foundation by adding layers of soil and mud. v. To dig trenches around the homes.	i. The cement layer reduces the effect of water on the wall, so most rural communities have low-income earners who may need help building a complete cement house. ii. Dykes help in the prevention or reducing the flow of water to their farmland, especially salt waters. iii. The local people believe that grass reduces the speed of water flood from the roof to the ground compared to corrugated roofing sheets. iv. This is the oldest method of house adjustment. They do this every first or second rainy season to reduce the direct contact of water with the walls of the houses. v. Trenches, according to the people, serve as water collectors to reduce the compound being flooded with water.
Changing of Livelihood	i. Early planting. ii. Keeping surplus seeds for replanting during post-flooding. iii. Lowland and upland crop cultivation	i. The people do this so that the crops can be strong and taller than the flood water thus reducing the total submerging of the crops in the field. ii. They anticipated that when a flood happens, some crops will be destroyed; thus, there is a need for them to keep some extra seeds to replant after flooding. iii. They do this to avoid a total loss, as in case of flooding, the upland crops will sustain them, and if there is a dry spell, the low-land crops will sustain them as well.
Management of livestock	i. Taking livestock to the uplands. ii. Making a raised platform ("banta-ba") for goats before the rainy season	i. They move their animals from lowlands to upland areas, knowing that the lowlands are more prone to flooding.

	iii. Not allowing cattle, goats, and sheep to graze in the swamps during the rainy season.	ii. This will prevent the animals from being carried away during flooding; hence, the platform is higher than the flood water heights. iii. They prevent their livestock from razing at swamps during the rainy season because some animals may get drowned in the deep waters.
Managing foodstuffs	i. Taking extra foodstuff to upland houses ii. Doing marketing and essential things before the heavy rains iii. Storing foodstuff in the house ceiling iv. Covering daily foodstuffs with a canvas (waterproof).	I. The local people do this during seasonal floods to avoid extra foodstuff to perish in case there is flooding. II. They get whatever is essential before the roads will be fully submerged in flood water. III. This prevents the water from touching the foodstuffs; hence, it is far from the ground. IV. Waterproofing is a of preventing the water from touching their grains in case water enters their houses before they arrive home.
Evacuating early	i. Move to the upland prior to the peak of the rainy season ii. Building temporary houses in the upland	i. People in the very lowlands moved to the upland to wait until after the rainy season. ii. People with mean build temporary houses in the upland before the rainy season; hence, their livelihood is around the river bank.

Note: Table 9 presents various early warning actions implemented by local communities in flood-prone areas of The Gambia.

As farmers are the most severely affected groups by flooding in The Gambia, most farmers tried to reduce the impact of flooding in many ways. For example, many farmers prefer to plant maise, millet, and sweet potatoes in the first rains to avoid the seedlings being affected by flood in the month of August as it is seen to be the peak of the rains in The Gambia.

III. Mechanism of flood risk reduction

While early action to flood is presented above as a way the local people take to observe the local EW indicators, research participants in all groups discussed means they used even without the local EW indicator but instead as a way of flood risk reduction. Among some of the areas the local people mentioned were; the strengthening of soil and river basin, local spatial planning, and adaptation to properties.

Most of the communities mentioned strengthening soil and river basins. The local people said that they engage in mangrove planting every season to prevent the river from encroaching into their farmlands. They also build physical barriers to prevent sediments from eroding into the river.

Secondly, in local spatial planning in nearly all the FGDs of both males and females, it was mentioned that people are mindful of leaving a distance from the river basin when constructing their houses. An average distance of 100 meters was agreed to be better. However, due to river encroachment, many houses are just less than a meter to the river during high tides (Figure 7).

Figure 7: Example of river encroachment of less than a meter to houses in Kuntaur Wharf Town-CRR North (author's own, March 2023)

Finally, adaptation to properties was also mentioned in the discussions. Foundation strengthening was commonly mentioned as they believed that it would make houses more resilient and robust to flood impacts when they had a cement foundation (Figure 8). The local people mentioned building houses where the face of the house will not face the direction of the rain, filling sandbags and placing them around the houses to reduce the directed contact of water to the wall, making rooks with all side slope to have a spread pouring of water on all side in other to avoid overflood in one side of the compound.

"*We try now to build houses with at least three courses of cement block then continue with mud blocks to avoid cracking of the houses during the rainy season or flooding*" (FDG, Kaba-Kamba, URR)

Among some of the adaptations mentioned was putting stones in the foundation before laying the block (either cement or mud block) to give a solid ground on which to support the structure even during flooding.

"*We sometimes put big stones in the foundation holes before we start laying the block as this will help in preventing the foundation from being over-wet during the rainy season*" (FGD Gionoi, LRR)

Figure 8: A sample of a mod house built with a strong foundation of cement brisk but was deroofed by a wind storm in Kaba-Kamba, URR South, (author's own, June 2023)

4.1.5 IK In During Flooding

This collective wisdom enables communities to act swiftly and efficiently during floods, reducing the loss of lives and property.

During floods, IK plays a crucial role in mitigating the impact of this life-threatening disaster and ensuring the safety and resilience of affected communities. Most of these IKs are not just cost-effective but also sustainable, thus making them very useful where modern infrastructure and social amenities are limited. This collective wisdom enables communities to act swiftly and efficiently during floods, reducing the loss of life and property. Below are some IKs identified from the local communities during flooding.

Monitoring

Based on the FGDs, local people indicated a strong connection in the observation of the real-time situation by observing the heavy rainfall, flow of water, and water level make any necessary response to the flood. In Kuntaur Wharf Town, for example, the people have a tree in the village where they monitor the Height of the water to determine if the rain continues, there will be a serious flood, so they quickly respond to the disaster swiftly (Figure 9).

"*We have one tree that when water passes a certain level, I start to prepare for a flood, so we quickly start moving our materials to safe places*" (FGD Kuntaur Wharf Town, CRR).

Figure 9: A Sample of a tree where the water level is monitored for flood response in Kuntaur Wharf Town-CRR (author's own, June 2023)

Decision to evacuate

In many instances, participant explains how they decide to evacuate when their houses are flooded. With a lot of challenges during evacuation as alluded to by many of the participants, decisions to move are made by the head of the household, and to where is always the major challenge. This is because there is no evacuation centre within the communities, as most of the victims are accommodated by neighbours and in schools if there are any.

"*We only move from our houses when the flood water enters inside our rooms. For example, last year (2022), water entered my room until the height of the water was near to the winder level*" (FGD Kuntaur Wharf Town-CRR).

Means of evacuation

Based on the decision to evacuate, it is clear that the respondents wait for the water to overflood before they start moving. The major means of evacuation, as mentioned by participants, is by walking and by donkey/horse cats.

"It is not easy to move during flooding; we have to carry our children (less than 5 years old) on our backs and walk to a safe place" (FGD Kaba-Kamba, URR).

"We most of the time use our donkey or horse cats to help relocate our materials to a safe place, and sometimes, if the water overpowers the animal, we use the strong boys to carry the materials (FGD Darsilameh NBR).

4.1.6 IK During Post-Flooding

As IK employed after flooding can be simply referred to as recovery in the disaster management cycle, local people have strategies to locally rebuild destroyed houses and restore their livestock, and livelihood.

This research indicates that houses are frequently rebuilt in the same places with little or no improvement in construction methods for various reasons. Firstly, the decision of the local people to build on the same piece of land is significantly influenced by the availability of suitable land for the victim's livelihood.

"*We build in the same place because we don't have lands as we are not the first settlers, and if we want to move and build far from here, we will be far from the river, and you know we are fishermen; this is our work".* (FGD Faraba Banta WCR)

Secondly, the local people believe that when they build houses in the same spot as the collapsed houses, the ground is often raised because elevated land is associated with being more resilient to floods than lowlands.

"*We do build the house on the same ground as this time the house is at a higher elevation than the collapsed house*" (FGD Faraba Banta WCR).

Finally, in Darsilameh, participants mentioned that lowlands are more fertile than highlands. Thus, the wild animals will quickly destroy their crops if they don't rebuild their houses near their farms. This indicated that the local people strongly depend on farming activities as their livelihood. This indicates that local people who rely on farming in flood-prone areas for their livelihood face a trade-off between the benefits of fertile floodplains and the risks posed by living in such flood-prone areas.

In the striving for recovery, the respondents commonly mentioned rebuilding temporary houses in floodplain areas as they wait to build solid houses when they have the finances to do so (Figure 10). "*We do this because we do not have money to build other stronger houses*" (FGD Faraba Banta WCR)

Figure 10: A sample of that collapse and the owner can afford to rebuild and use a temporary corrugated sheet in Faraba-Banta WCR (author's own, November 2023)

After the floods, the primary focus for community members in The Gambia local communities along the river is to plant crops in flood-prone areas to secure food. With limited income and livelihood options, they prioritise returning to farming activities that sustain their living. As frequently mentioned across all FGDs, residents use residual moisture to plant seeds such as maize, beans, and rice. Once the floodwaters recede, they wait for the mud to dry before preparing their fields and planting.

Recovering after floods presents significant challenges for local communities in The Gambia. As one participant from a focus group discussion in Darsilameh stated, "*Life gets back to normal, but it is hard since a lot of things have been damaged. It takes time for things to normalise." Replacing losses, particularly livestock, is difficult due to high poverty levels. To generate income and recover more quickly, individuals often engage in casual labour on other people's farms, earning funds to buy seeds and restart their farming activities."*

Before receiving relief aid from any NGOs and the government, communities rely heavily on mutual support. Female participants from Dasilameh described how those who lost their food purchased small portions from other community members to sustain themselves until help arrives

4.1.7 The important IK

This section will present the answers provided by the local community members on the importance of IK to them. In trying to capture their response, the importance of IK is divided into five categories.

Firstly, the local people mention the importance of IK as it helps them prepare for any anticipated disaster. This shows a very strong explanation that the local people have their own way of preparedness for floods. All the participants believed that if all people followed the local EW indicators, the probability of the flood having a great impact on them would be minimal. As stated by a male participant in Kuntaur Wharf Town, "*Before flood happens, we already used to know a day or some hours before it happens*". This has demonstrated a strong confidence in the local people that they can cope with the effect of the flood because they know before they are hit by flood even though it overwhelms them in many cases, as mentioned by a female participant in the same village "*Honestly, we have means to know whether there will be a flood, but even when we prepared in many cases water will always find ways to enter our houses and farms and damaged many things*".

As mentioned by participants, IK helps those people who are living in very lowlands to prepare by moving their belongings to a safe upland thus taking early action as discussed in the previous subsection.

"*The IK helps us start moving our perishable materials to a safe place before the water enters our houses*" (FGD Jenio LRR)

They strongly believe that having early knowledge of any disaster raises awareness in the local communities as they lamented that there is no modern early warning system (EWS) in their communities, thus making them treasure the IK hoping that it will continue to make them prepare for any foreseen disaster.

"*The important thing is IK makes us prepare early to move before the flood spoiled all our materials although we can not carry all the materials, causing some to be damaged by flood* " (FGD Dasilameh NBR)

In addition, the local people stated that any person who refuses to take early action based on the local EW indicator is always seriously affected by floods, and this has happened to some people who used to doubt the IK in their communities.

"Some people don't want to believe the IK because they think they are educated, but when the local people warn them and refuse to take the advice, they always see the consequence of disobeying the elderly wisdom "**.**

The second category of the importance of IK to the local people is cultural ownership of the knowledge. There is a strong sentiment that the local people own the IK, and it is believed to be rooted in their culture and needs to be respected.

"*We received this knowledge from our grandparents, so it is part of our culture, and it needs to be respected; that is why we continue to teach it to our children* " (FGD Kaba-Kamba URR). As the local people relate the IK to their culture, there is a need to consider the cultural aspect of any DRR policy in The Gambia.

Thirdly, IK helps in both traditional and cultural education and awareness of any society. As alluded to by many participants, IK Is a wisdom and it needs to be taught to the younger generation. They also believe that IK can instill discipline in the people as they are taught how to be rules-abiding.

"*Our cultural knowledge is important because it teaches us to be people that will follow the rules set by our grandparents*" (FGD Kuntaur Wharf Town)

They mentioned that IK helped in the self-awareness of the identity of the people, stating that if anybody did not have knowledge of the local people, that person is not fully cultured by their culture, thus making his/her disobeying some old wisdom.

"*We know people whether they have IK by identifying them on the knowledge they have in our cultural knowledge* " (FGD Kuntaur Wharf Town).

Fourthly, IK is very Cost-effective and available for use by the people in the society. As the knowledge is passed from generation to generation in a very cultural way unlike the modern knowledge where there is a cost in acquiring knowledge, the local people are privileged to acquire the IK free of charge.

"*We teach our children this knowledge to them is anywhere at any time because we are with them always* " (FGD Kaba-Kamba URR).

The local people have seen that teaching their IK to the young does not need any payment or external formal means. As they interact with the children, the teaching is going on effectively. They also mention that their knowledge does not require literacy before they can acquire it or use it best.

“*Our know did not as whether you can write or write before you know it; it is part of us, and we live with it daily*” (FGD Faraba Banta WCR).

Finally, IK helps in the Knowledge on historical identification of the local people as most of their knowledge is related to their livelihood and cultural activities. According to the IK helps in knowing the origin of a person as whether the person is a fisherman or a farmer.

A fisherman in FGD Kuntaur Wharf Town said, "*Like the knowledge of a farmer will be different from us as a fisherman because we look at the moving of water and sky to read sign whether there will be plenty fish or not*."

A farmer among the participants in FGD Kuntaur Wharf Town has this to say: *"We also study the sign of leaves of trees to determine whether the rain will come soon or not."*

Based on the two participants' different livelihoods, one can tell that IK can tell an individual's history as it relates to their society and socioeconomic status.

Table 10: Summary of the categories of mentioned importance of IK to the local people

Categories	Discussions
Preparedness to disaster	IK in The Gambia plays an important role in enhancing community preparedness for floods. Indigenous communities often possess time-tested strategies and practices that have been developed over generations to anticipate and respond to flood events. These practices can include local EW indicators, community mobilisation techniques, and resource management strategies that can significantly reduce the impact of floods.
Cultural ownership of the knowledge	The ownership of IK in the study area fosters a strong sense of responsibility and stewardship over the environment. This cultural ownership ensures that the knowledge is respected, preserved, and effectively utilised. When communities feel ownership over their flood management strategies, they are more likely to participate in and sustain these practices actively.
Traditional and cultural education and awareness	IK is often transmitted through traditional and cultural education systems in The Gambia. This form of education ensures that younger generations are aware of and understand flood risks and management techniques. It also promotes a continuous cycle of learning and adaptation, which is vital for maintaining resilience in the face of changing environmental conditions in the local communities.
Cost-effective and available	IK is very cost-effective as it relies on locally available resources and techniques. These practices do not require expensive infrastructure or technology, making them accessible to even the most resource-constrained communities of persons. This cost-effectiveness ensures that flood management strategies in the local communities in The Gambia can be implemented and sustained over the long term.
Knowledge of historical identification	Local communities in The Gambia often have extensive historical records of flood events, including patterns and impacts. This historical knowledge is invaluable for identifying flood-prone areas, understanding flood dynamics, and developing appropriate mitigation strategies in their community. With this historical insight, communities can better predict and prepare for future flood events.

Table 10 highlights key discussions on the role of Indigenous knowledge (IK) in flood preparedness and management in The Gambia. It emphasizes the importance of cultural ownership, traditional education, cost-effective strategies, and historical knowledge in enhancing community resilience to flooding.

SECTION 2: Objective 2: To assess the flood risk of the communities in The Gambia

4.2.1 Flood Risk Areas:

To identify areas at risk of flood, we scaled the level of flood risk into five levels (Table 4). The first level was "very low flood risk". In this stage, 510.112 km^2 (5.271%) were identified. The main reasons for the low risk of the flood were greater distance from the river, a higher topography compared to the fifth level (very high flood risk), lesser rainfall, and lesser population density. The second level of "low flood risk" covered an area of 3471.748 km^2 (35.875%) of the study area. This area was characterised as an area that does not have many human activities, with average rainfall and a gentle slope topography. Thirdly, the "moderate flood risk" areas feature the probability of flood risk when triggered by human activities like land degradation and other socioeconomic activities. In these areas, the area topography and rainfall continually vary and thus dictate the level of flood impact and the reoccurrence of food sources. The area of this level covers 3649.325 km^2 (37.710%). The fourth level (high flood risk) covers an area of 1791.300 km^2 (18.510%). There were many factors influencing the high-risk status in this area, such as the lack of proper infrastructure, high population density, heavy rainfall, and poor drainage system. The last level of "very high risk" covers an area of 254.740 km^2 (2.632%), which is primarily urban but also includes some parts of the north bank region. The key driving factors for the very high-risk area include the factors of the fourth level mentioned above, along with those of buildings in flood-prone areas, poor waste management, very low elevation, sandy areas, and poverty of the urban population.

4.2.2 Elevation Parameter:

The main factor used to examine the flood risk areas in The Gambia was elevation. It is obvious that areas with high elevation are less prone to flooding, while areas with average or low elevation are highly susceptible to flooding. In comparison to other countries, The Gambia has a generally low elevation. In this study, areas that are far from the river have relatively higher elevations than areas that are closer to the river. CRR North, CRR South, and URR are seen to have higher elevations than KM, Banjul, and WCR (Figure 11). (Vatseva *et al.*, 2015) agreed that higher elevations are less vulnerable to flood, while low elevation areas are more susceptible to flooding.

As shown in this study, the western part of The Gambia is more prone to flooding than the eastern part of the country.

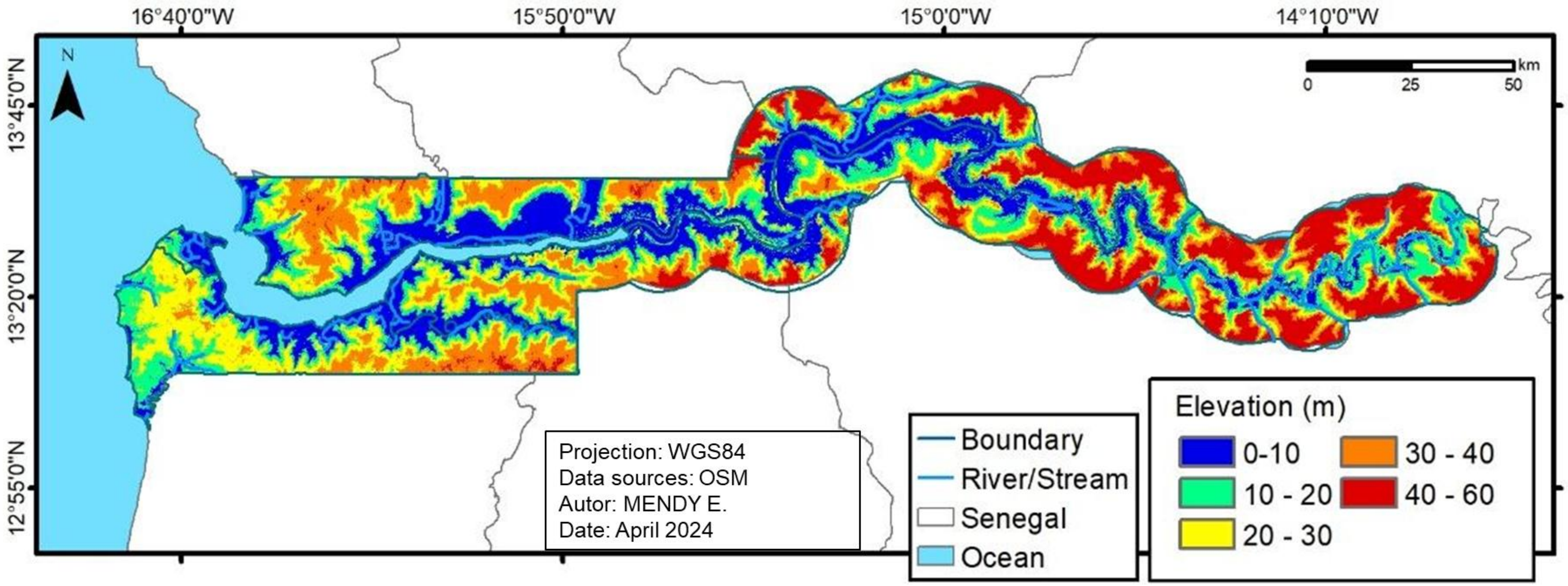

Figure 11: Elevation map

4.2.3 Rate of slope for susceptibility to flooding parameter:

The slope of an area, often referred to in terms of topography, is a measure of how steep a particular portion of land is. It is a crucial factor in fields like flood disaster risk assessment and environmental planning because it affects water drainage, soil erosion, building design, and land use planning. The slope has an excellent influence on determining flood risk because it controls the amount of surface drainage (Hagos *et al.*, 2022; Basyar *et al*., 2021; Saaty, 2008). A very steep slope can quicken the rate of water flow because it lessens the rate of water infiltration. The slope in the study area varies from 0˚ to ≥10˚. Looking at the results (Figure 12), the highest slope in the study area ranges from 5 to 9. At ≥5, areas were designated as high flood risk. Geographically, communities that are close to the river and in the heart of the urban area are considered to be at high risk due to their proximity to the river.

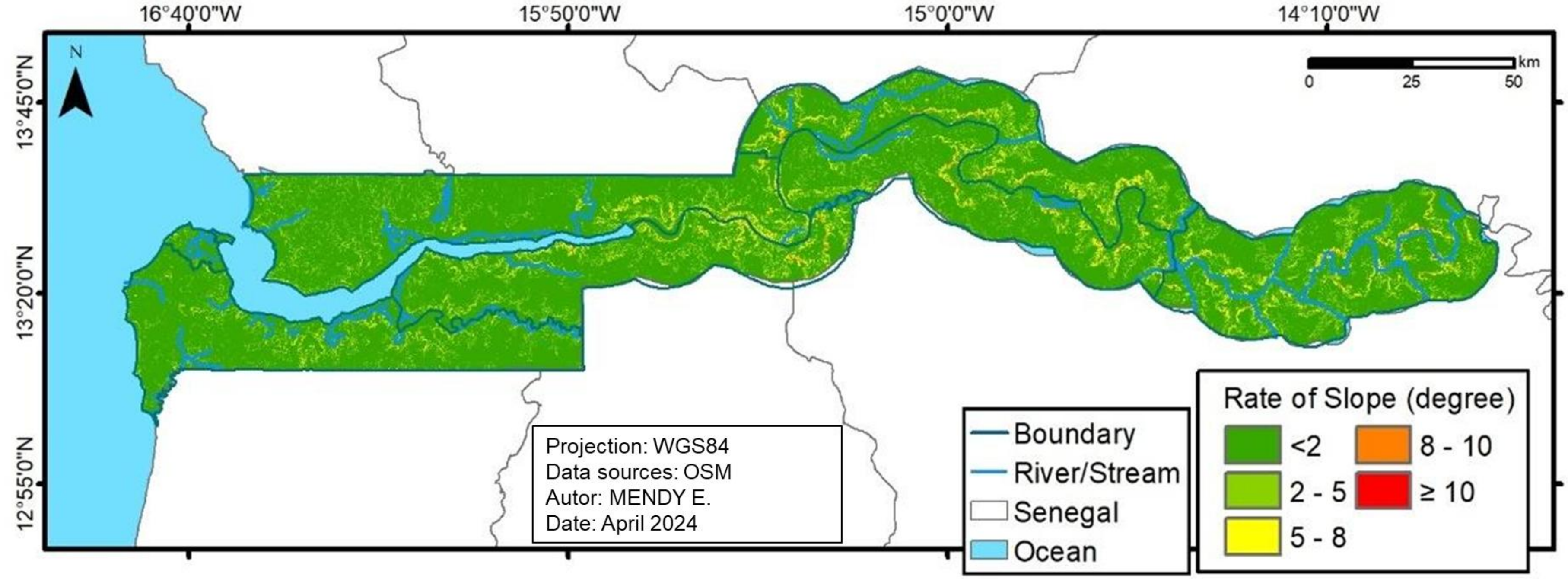

Figure 12: Rate of slope for susceptibility to flooding

4.2.4 Land-use/land-cover Parameter:

Flooding is either slowed down or accelerated depending on the type of LULC in any given area. The LULC types of this study area are mainly croplands, rangelands, built areas, and a few tresses. The land use and land cover categories - encompassing built areas, farmlands, flood vegetation, bare ground, water, trees, and rangeland - exhibited varying degrees of susceptibility to flood risk within the investigated region (Figure 13). Geospatially, the eastern area and the NBR of the study area demonstrated more farmlands, thus making the agricultural activities vulnerable to flooding. This outcome aligns with findings from prior research (Ayenew & Kebede, 2023), indicating a greater vulnerability of agricultural areas to flooding.

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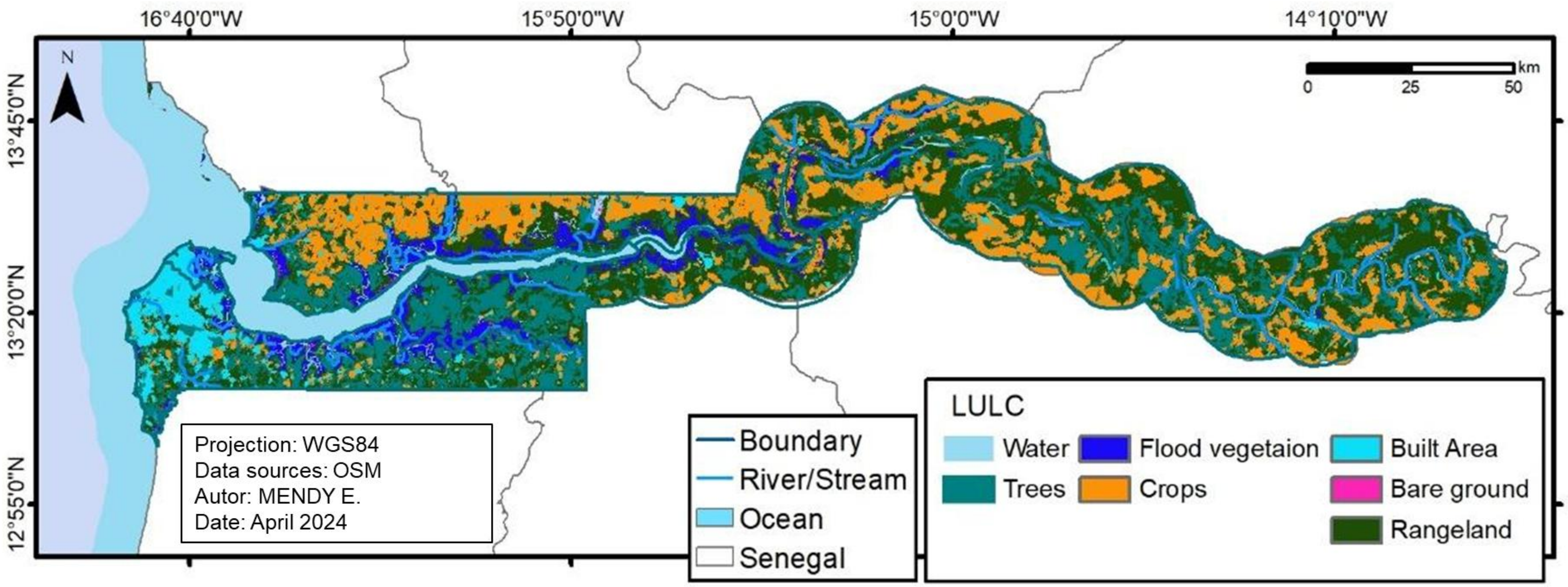


Figure 13: Land-use/land-cover map

4.2.5 Soil Type Parameter:

This Parameter stands out as a pivotal factor in delineating areas prone to flooding, exerting considerable influence on both the rate of water infiltration and its retention capacity. Within The Gambia, four primary soil types were identified: fluvisols, luvisols, nitosols, and regosols; these types were further distinguished as eutric fluvisols, thionic fluvisols, ferric luvisols, gleyic luvisols, distric nitosols, and eutric regosols (Figure 14). (Bahddou *et al.*, 2023 & Chen *et al.*, 2013) underscore the significant role of infiltration in shaping the availability and volume of surface runoff resulting from rainfall. Accordingly, clay-rich soils exhibit notably slower infiltration rates when compared to sandy soils (Ren *et al*., 2023). Fluvisols are mostly seen in large quantities around the river basin, while geleyic luvisols are mainly seen around southern LRR and CRR. Ferric luvisols are found in both the north and south of CRR but have a little extension in southern URR.

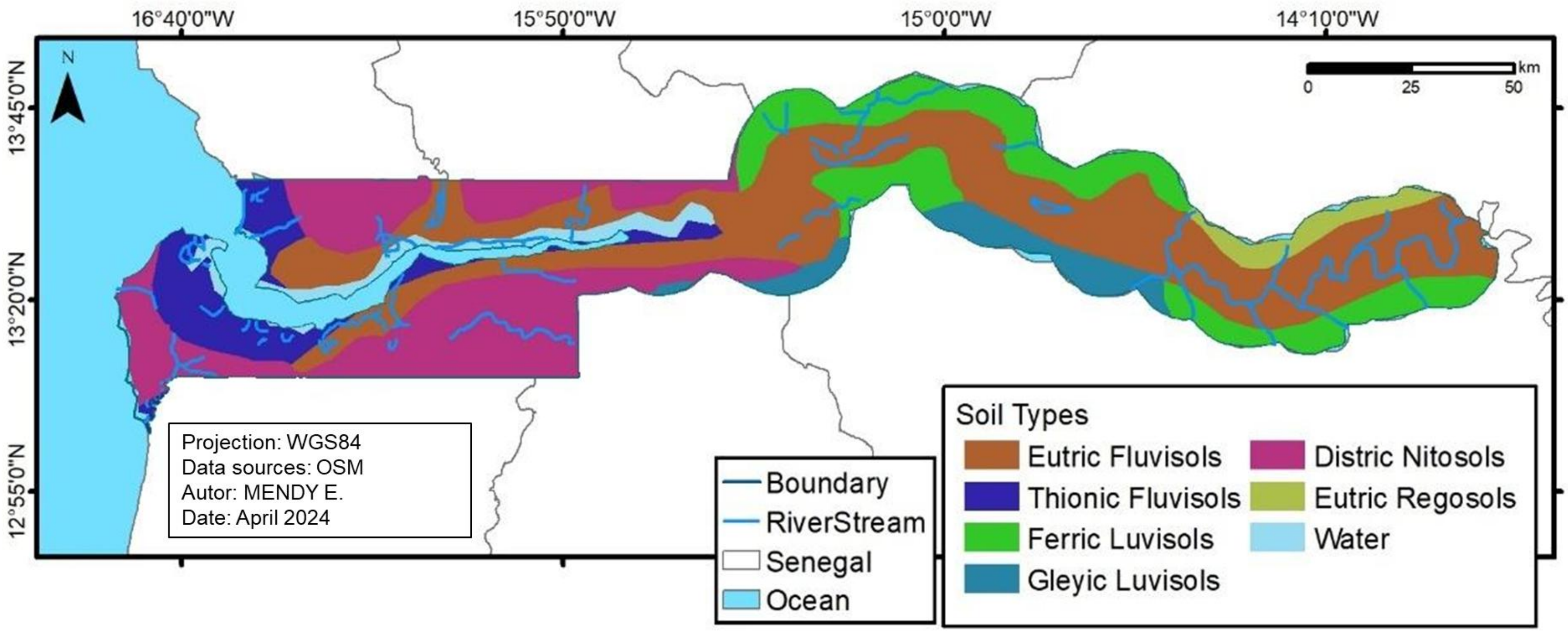


Figure 14: Soil type map

4.2.6 Rainfall Parameter:

Variability in rainfall and its ramifications on agricultural practices and water resource management are pivotal considerations within climate studies in The Gambia, a small West African nation heavily reliant on rainfall for its agricultural activities.

The primary mechanism for recharging the extensive groundwater system is precipitation in The Gambia during the wet season (Zhang *et al*., 2016). Regions in The Gambia that are experiencing higher rainfall are more susceptible to flooding, contrasting with areas receiving less precipitation. Rainfall is notably prominent in the WCR, KM, and some parts of northwest NBR (Figure 15). Seasonal inundation occurs during summer in the study area, facilitated by heavy rainfall and other underlying factors that trigger flooding. Rainfall amount, duration, and spatial distribution in catchments significantly influence flood risk in The Gambia, as mentioned by (Breinl *et al*., 2021). This does not change the fact that The Gambia has only a few months of rainfall and low rainfall compared to other countries in the sub-region.

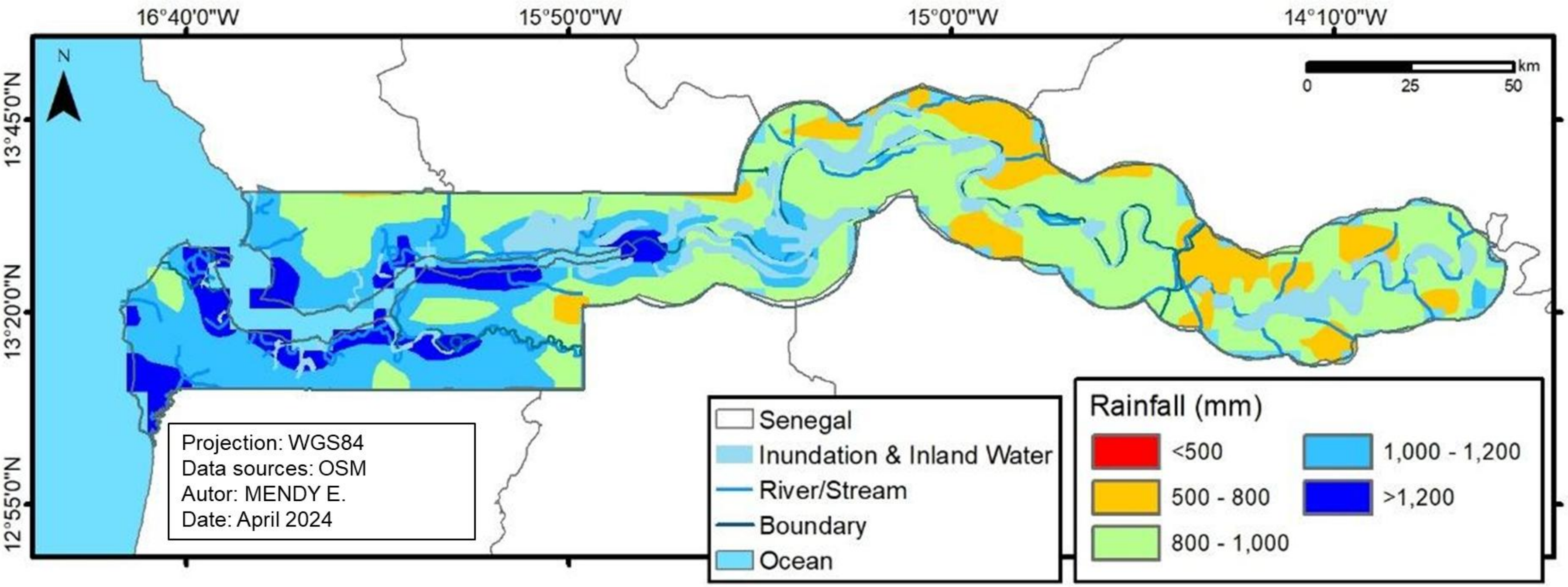


Figure 15: Rainfall distribution map

4.2.7 Distance from the River Parameter:

Emerging from the elevated terrains of the Fouta Djallon plateaus within Guinea, the river traverses the study area, dividing it into two parts. Its lower basin encompasses more than 35% of the nation's total landmass, rendering it susceptible to inundations. The region's subtropical climate, characterised by rainy seasons spanning from June to October, amplifies the river's propensity for overflow, particularly when augmented by elevated tides and the escalation of sea levels. These elements, compounded by anthropogenic interventions such as deforestation and substandard agricultural practices, heighten the susceptibility to riverine and coastal inundations, significantly impacting the populace residing in proximity to these waterways and coastal zones. Undeveloped low-lying areas adjacent to rivers face heightened vulnerability to flooding as water levels surge. Consequently, flood risk diminishes with greater distance from the river, while proximity to the river augments the likelihood of flooding (Figure 16). This observation aligns with the findings by (O'Neill *et al*., 2016), who noted that distance from the river can determine the level of flood risk. The study area exhibited high river density, rendering it prone to flood inundation. Notably, the western part of the study area faced greater flood risk compared to the eastern part of The Gambia.

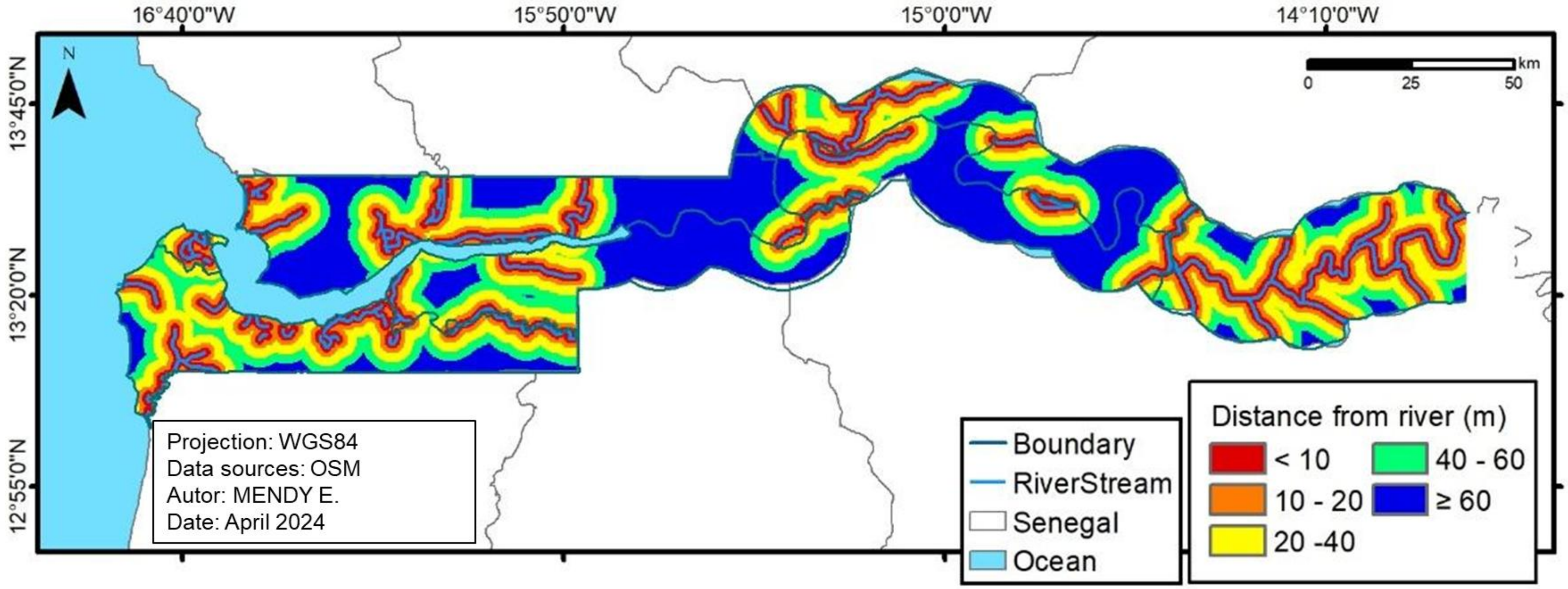


Figure 16: Distance from river map

4.2.8 Areas covered by flood during extreme rainfall-induced riverine flooding in various regions

Figures 17, 18 19, 20, 21, 22, 23, and 24 illustrate maps of flooded areas in regions such as Banjul city, Kanifing, WCR, LRR, NBR, CRR South, CRR North, and URR Respectively. These show water bodies and a red buffer (meters) zone of 92.5, 160.5, 172, 172.5, 166, 92, 164.5, and 75.5 respectively around the water bodies. These buffer areas are a representation of areas covered by water during extreme flood events. This buffer shows areas that are susceptible to flooding. With these buffer meters, flood risk areas are spatially identified in the various regions in The Gambia.

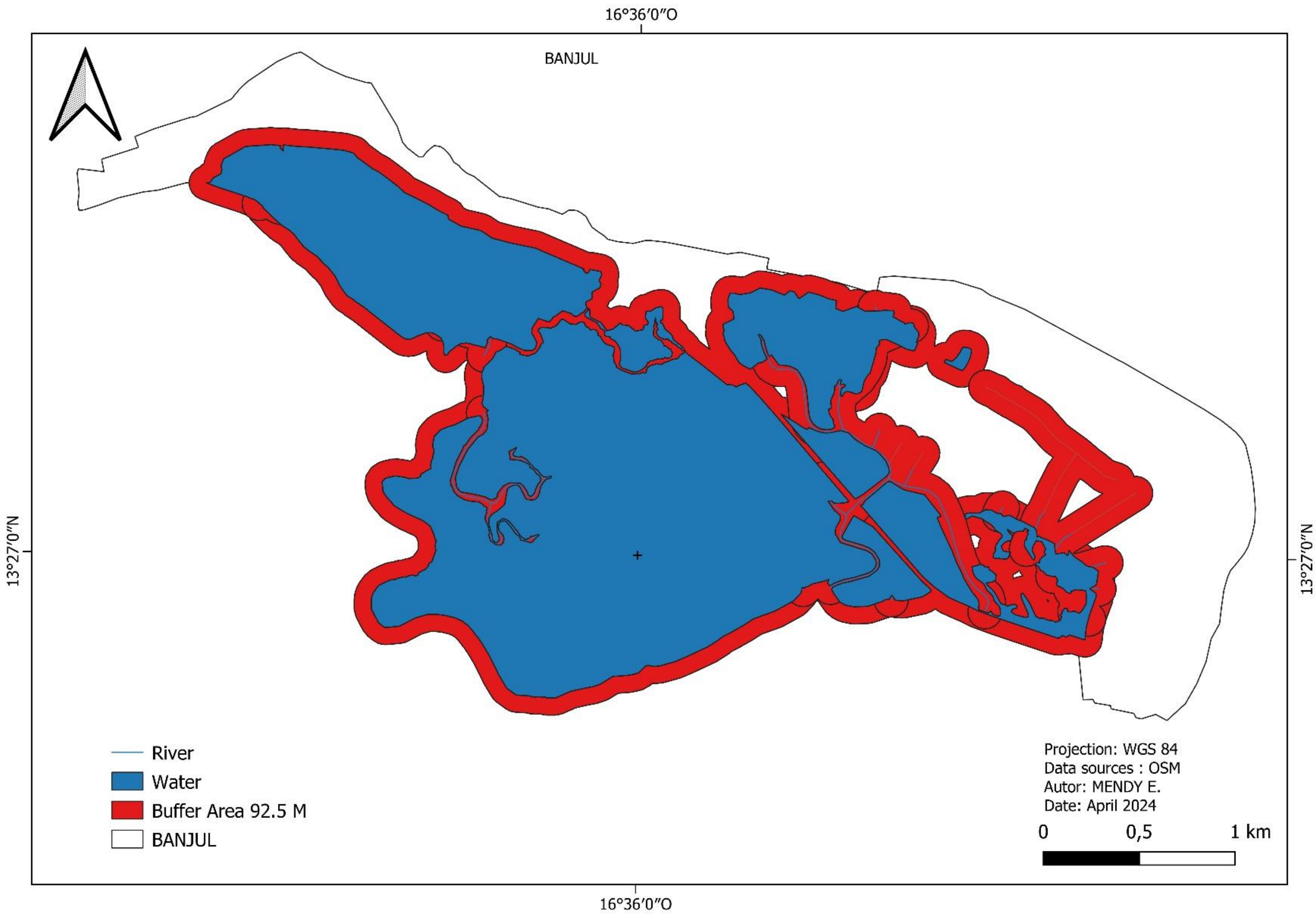


Figure 17: Banjul Map showing a buffer area of flooded land

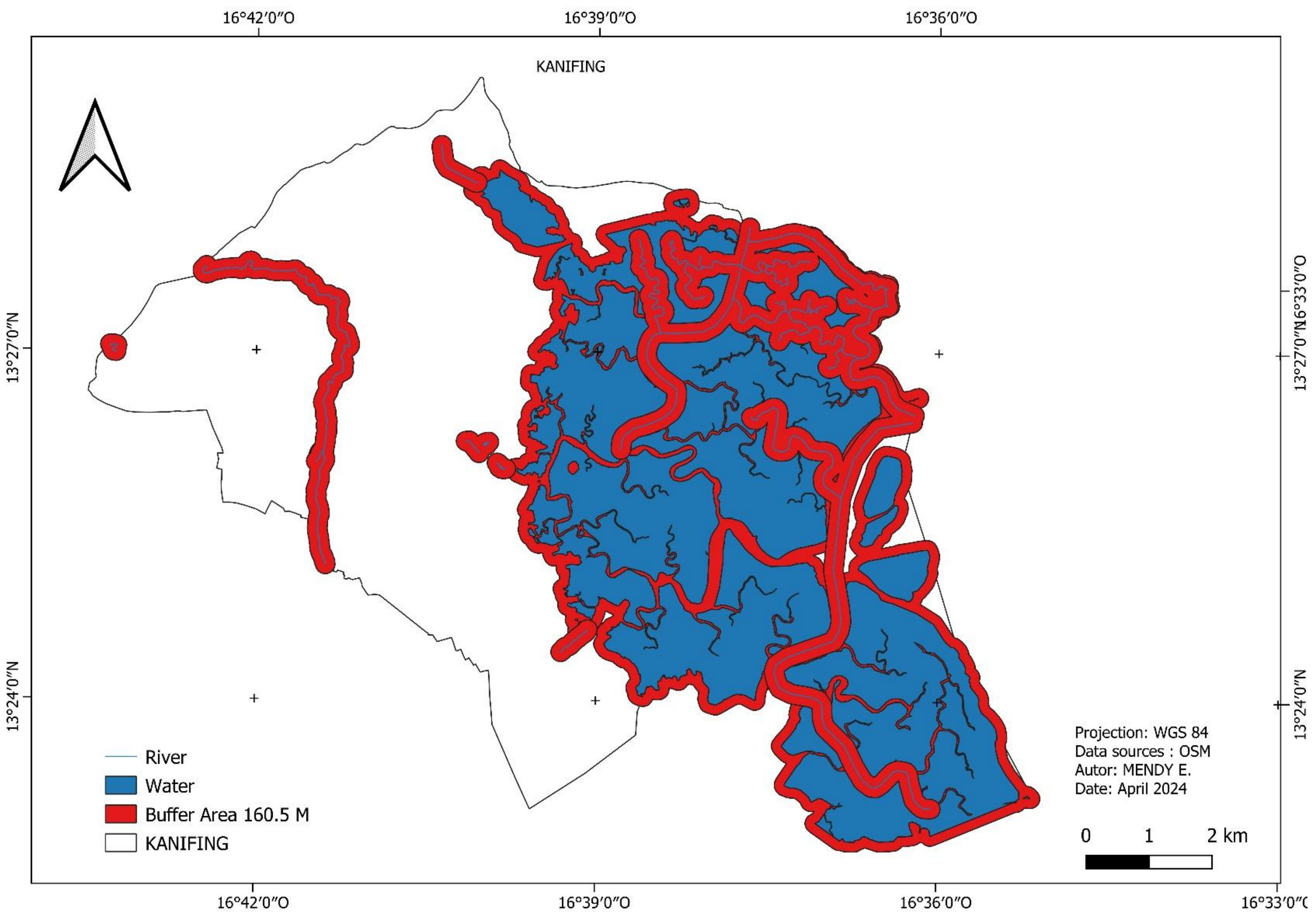


Figure 18: Kanifing Map showing a buffer area of flooded land

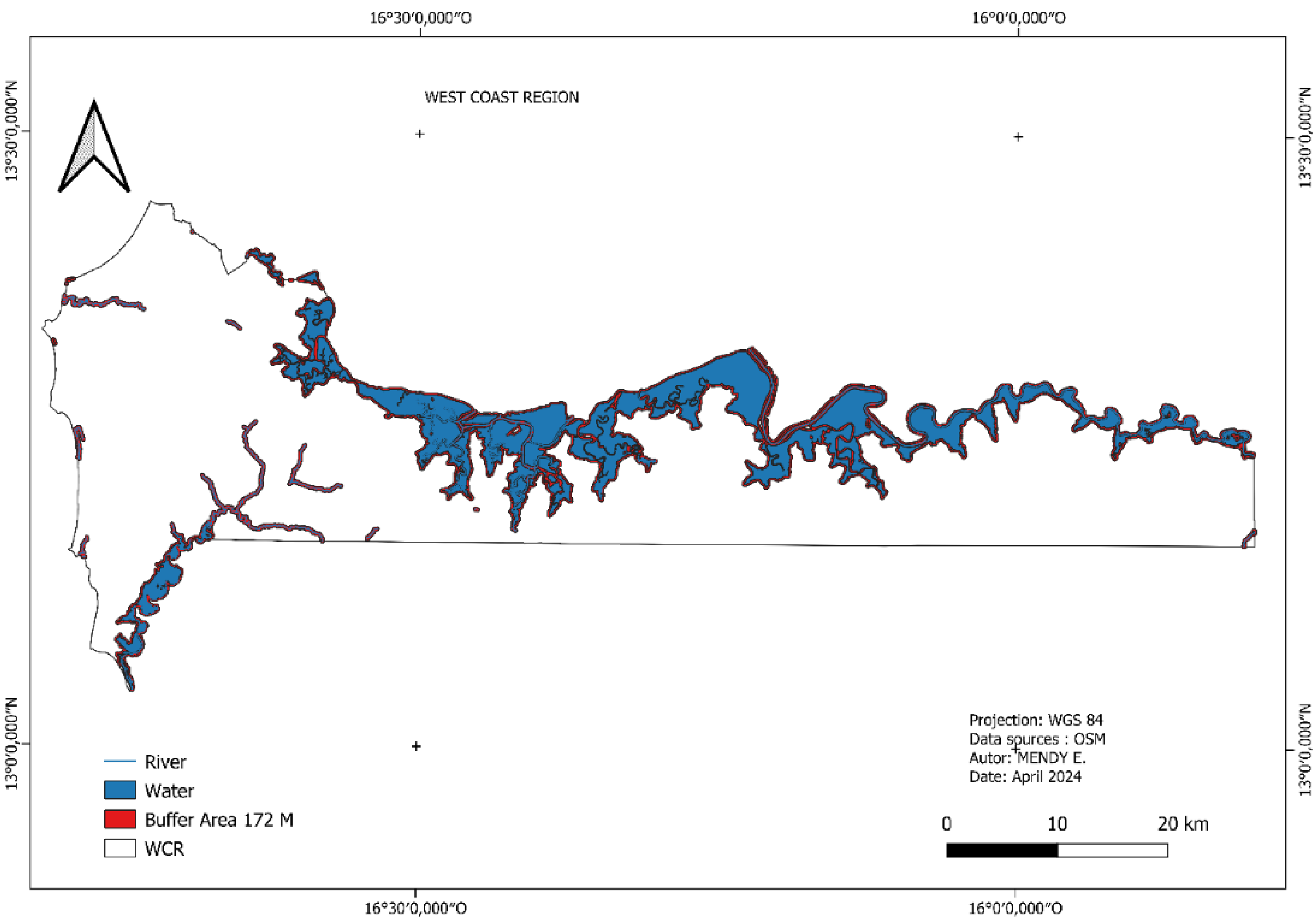


Figure 19: WCR Map showing a buffer area of flooded land

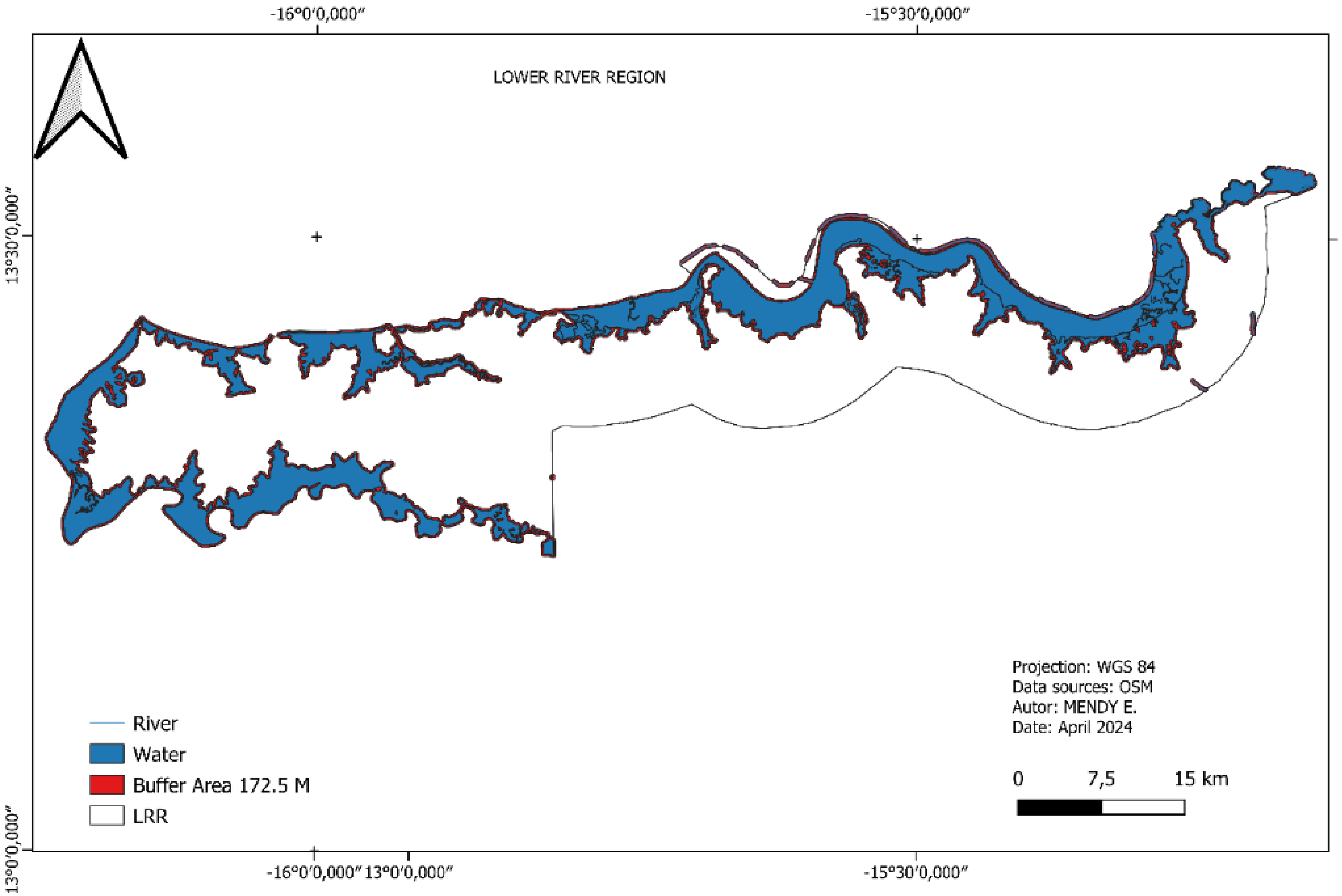


Figure 20: LRR Map showing a buffer area of flooded land

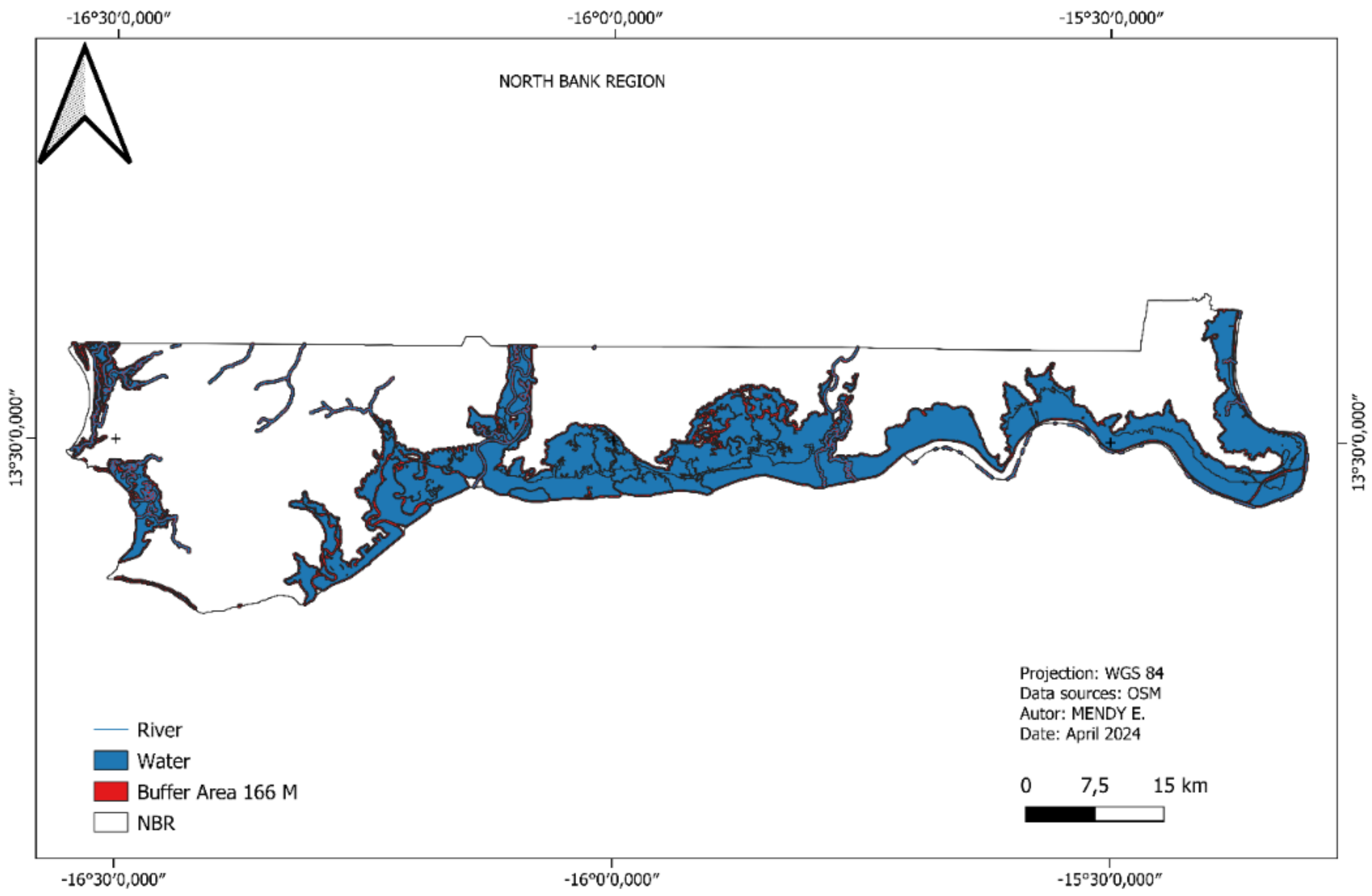


Figure 21: NBR Map showing a buffer area of flooded land

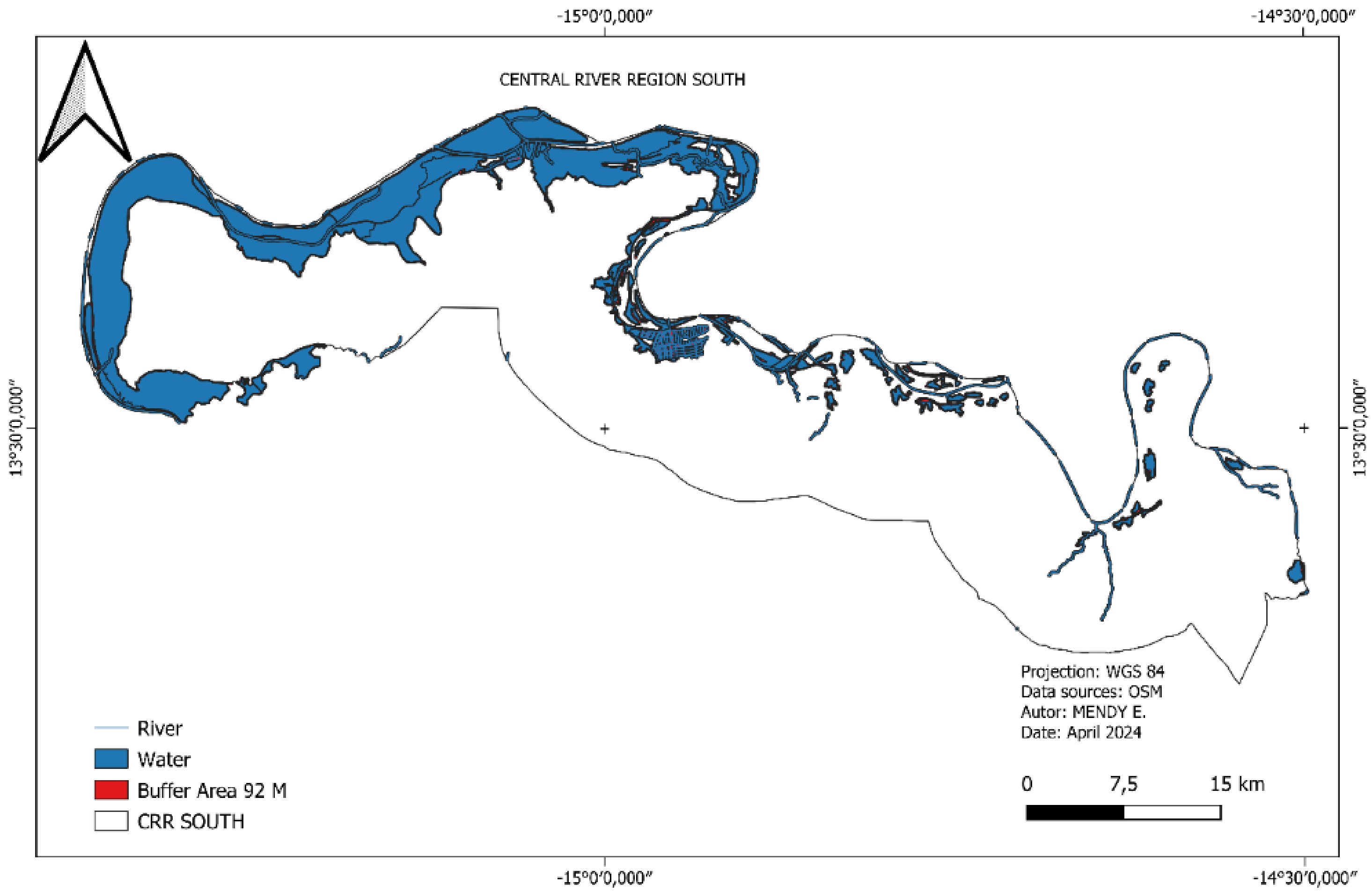


Figure 22: CRR South Map showing a buffer area of flooded land

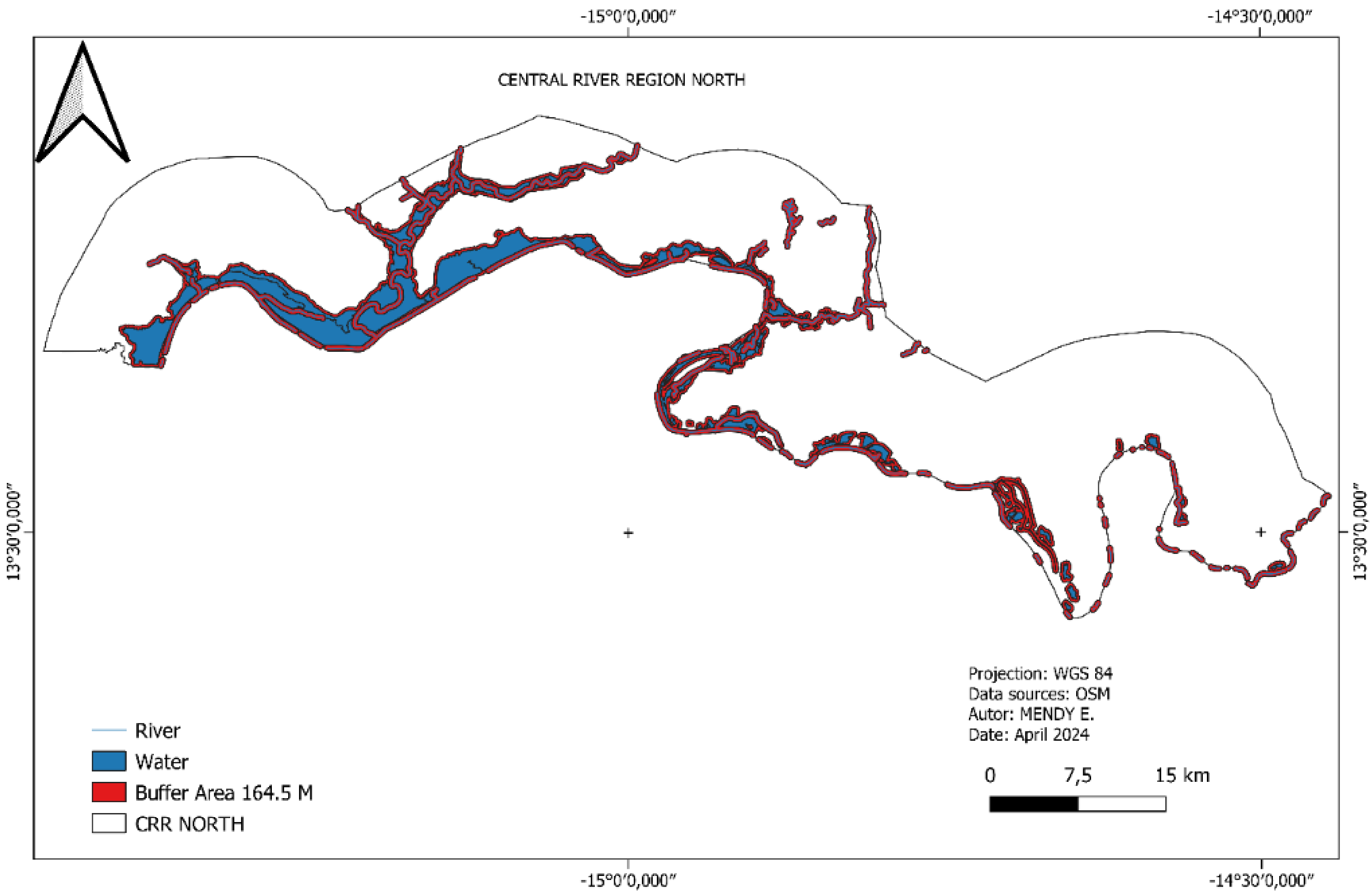


Figure 23: CRR North Map showing a buffer area of flooded land

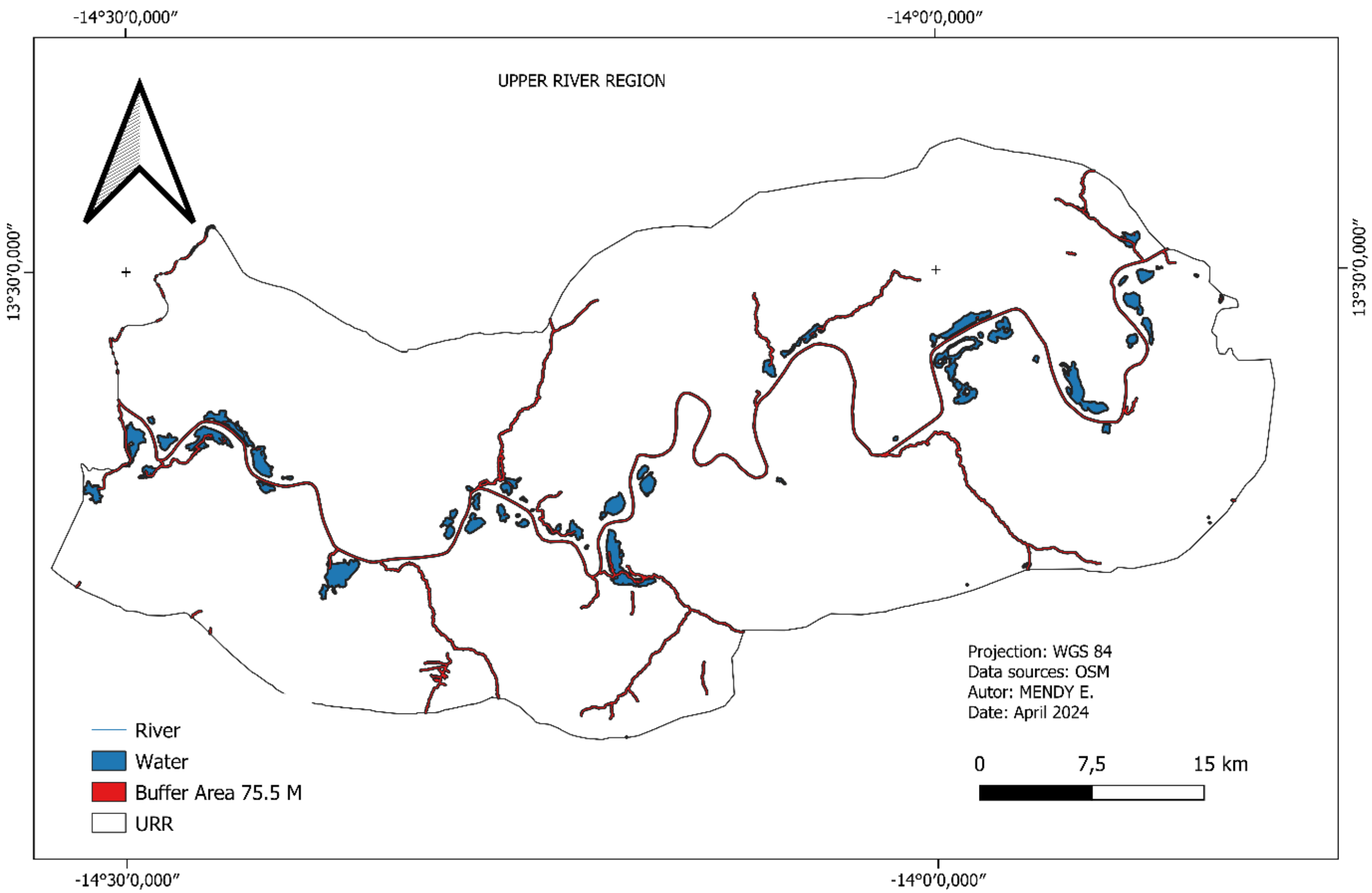


Figure 24: URR Map showing a buffer area of flood

4.2.9 Potential flood risk map of The Gambia.

Weight and rank values were allocated to elements and classes in the case study based on their significance. The composite map, derived from the values of the combined components, was segmented into different categories representing flood susceptibility levels: very low, low, medium, high, and very high. To compute the area for each vulnerability category, the "Zonal Statistics" tool within ArcGIS was utilised to determine the total area encompassed by each vulnerability category. According to the flood risk map (Figures 25 & 26), the study area was delineated to exhibit the following flood risk levels: very high, covering 254.740km^2 (2.632%); high, encompassing 1791.300km^2 (18.510%); moderate, occupying 3649.325km^2 (37.710%); low, comprising 3471.748km^2 (35.875%); and very low, accounting for 510.112km^2 (5.271%). Figure 27 and 28 With the moderate flood risk level as the greatest percentage of land area, followed by the high level of risk, this map shows that if proper mitigation measures are put in place, flood disasters can be fully managed if not prevented (figure 29 and 30).

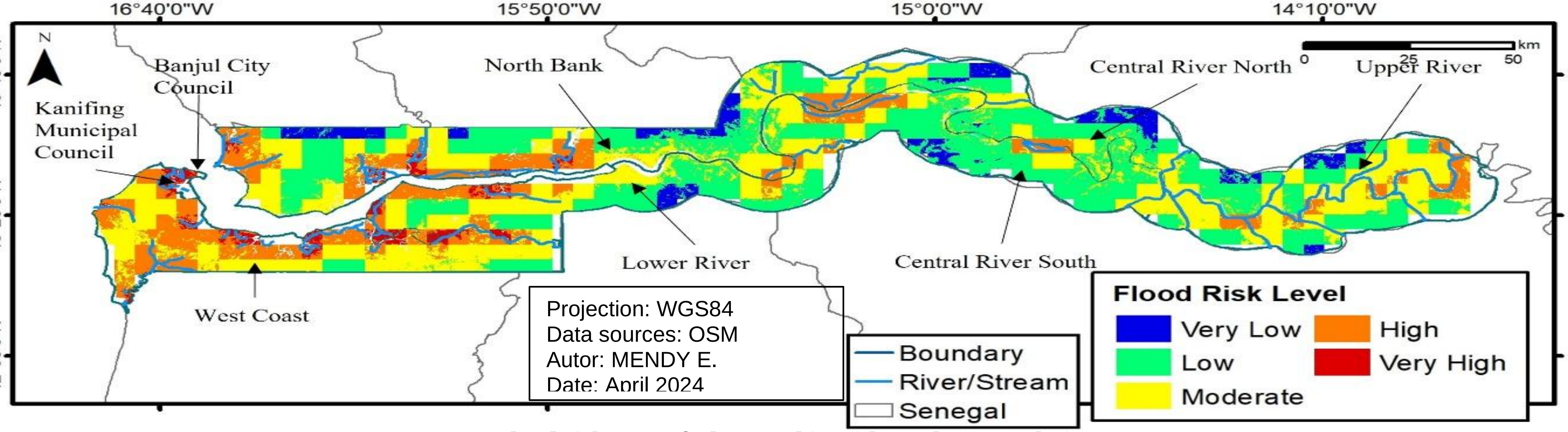


Figure 25: Flood risk map of The Gambia without the poupulation

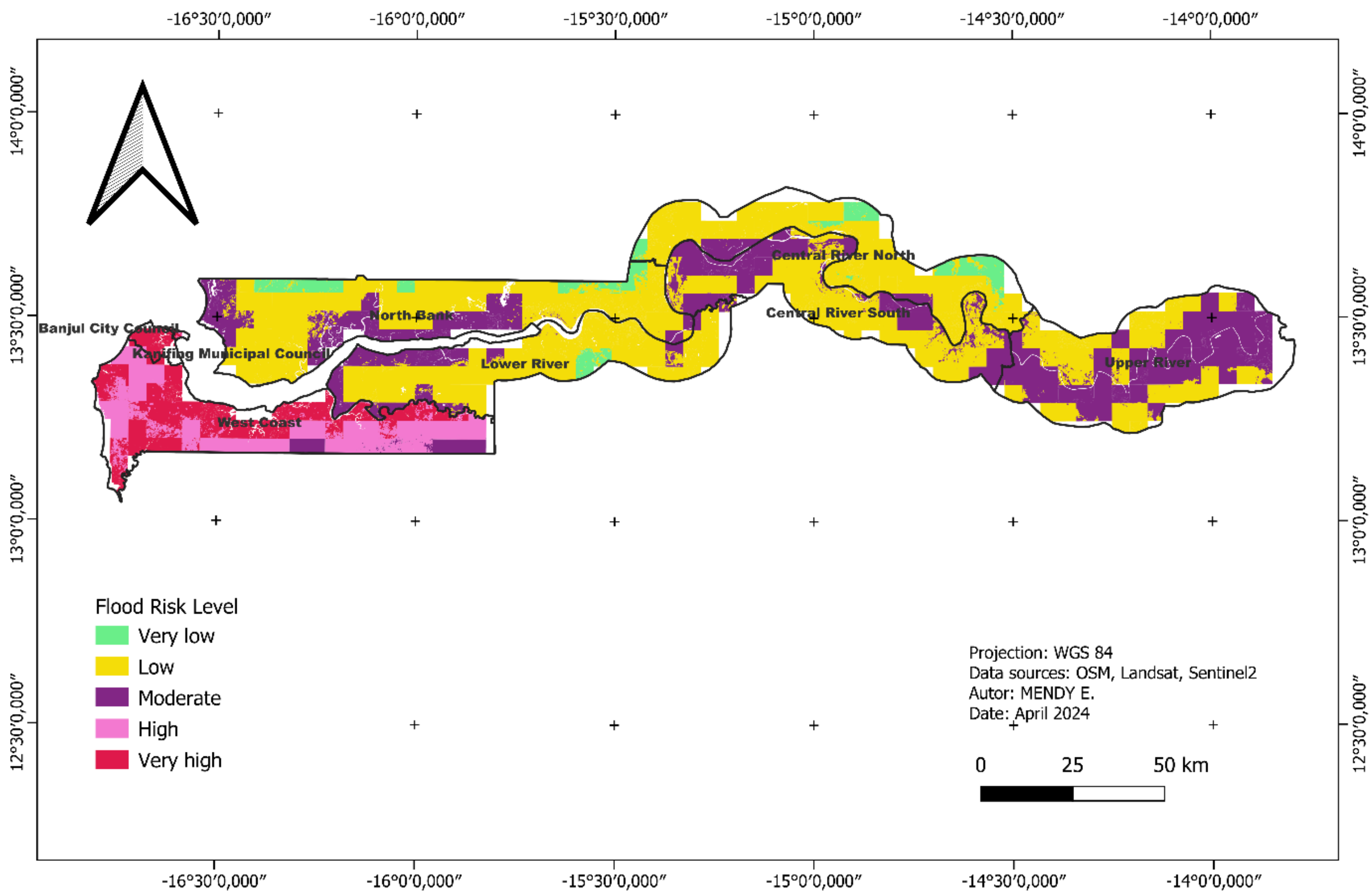


Figure 26: Flood risk of The Gambia covering the population

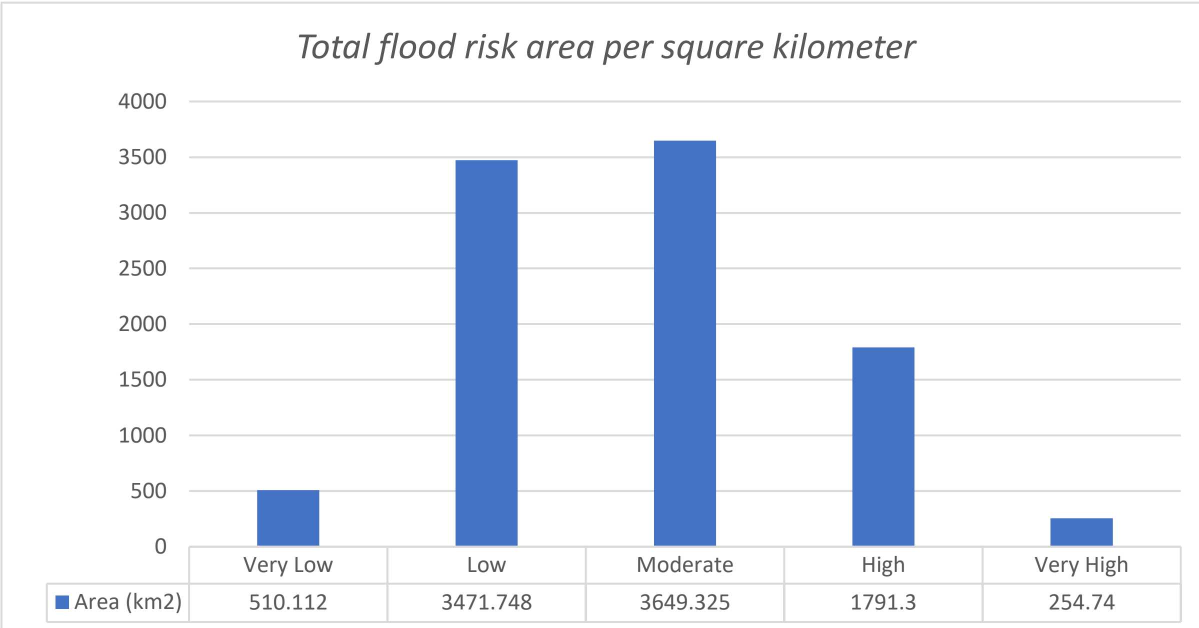


Figure 27: a bar chart of total flood risk area per square kilometer in The Gambia

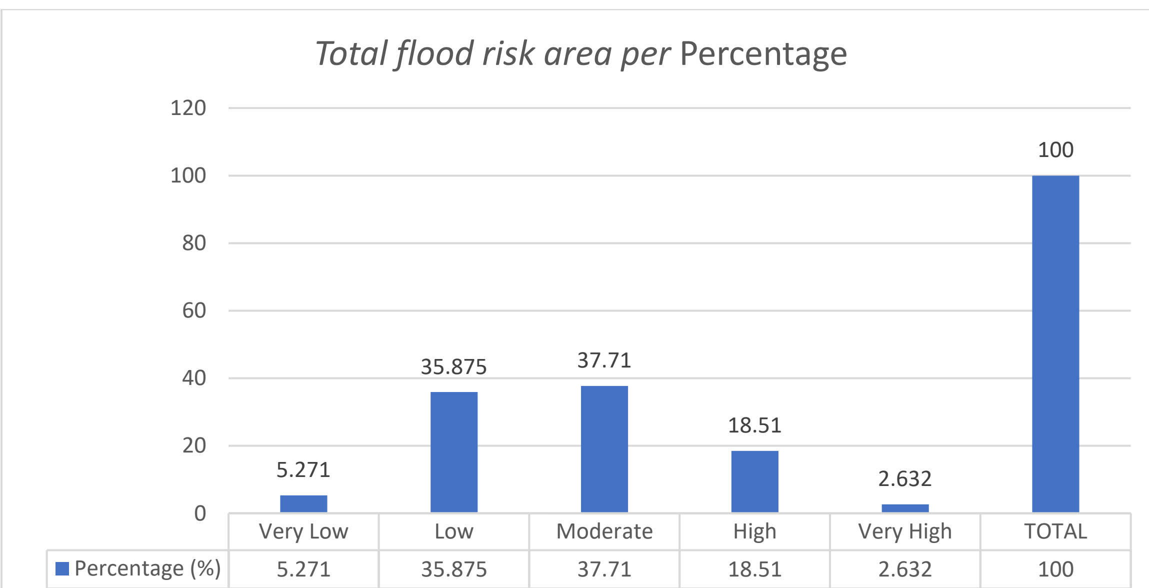


Figure 28: A bar chart of total flood risk area per percentage in The Gambia

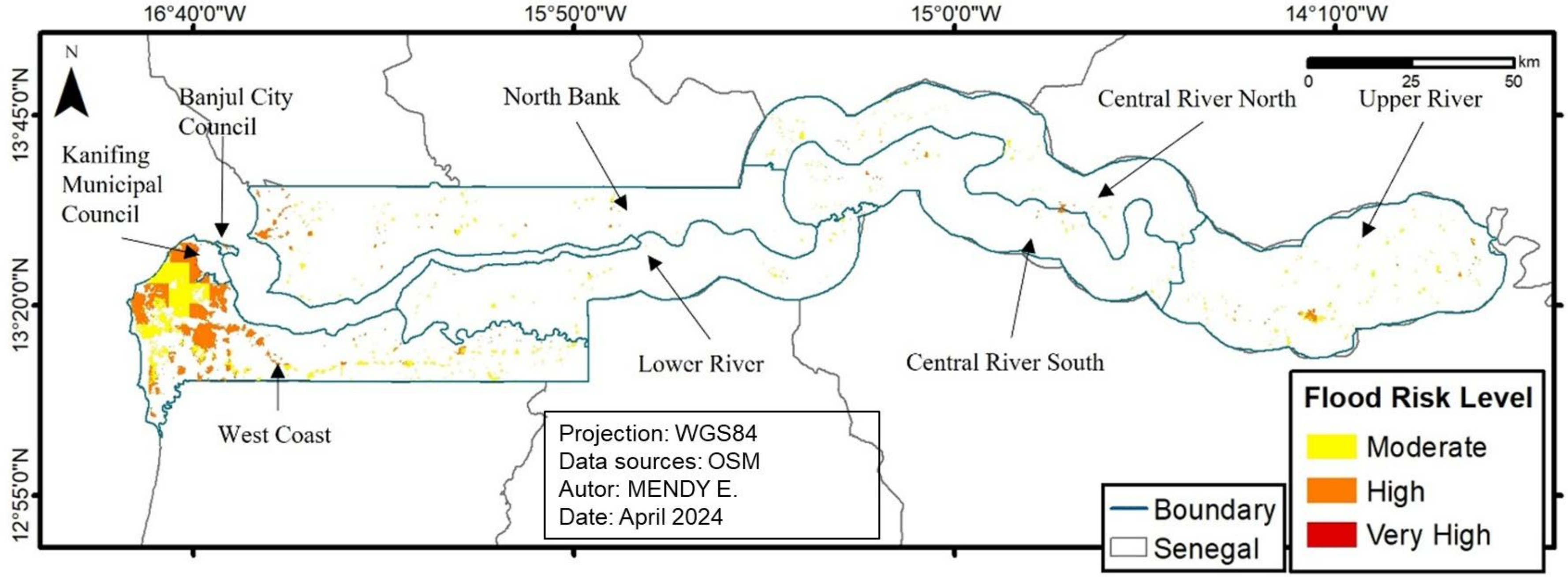


Figure 29: Flood risk map of moderate, high, and very high-risk level areas with overlaid built area from land use/land cover data

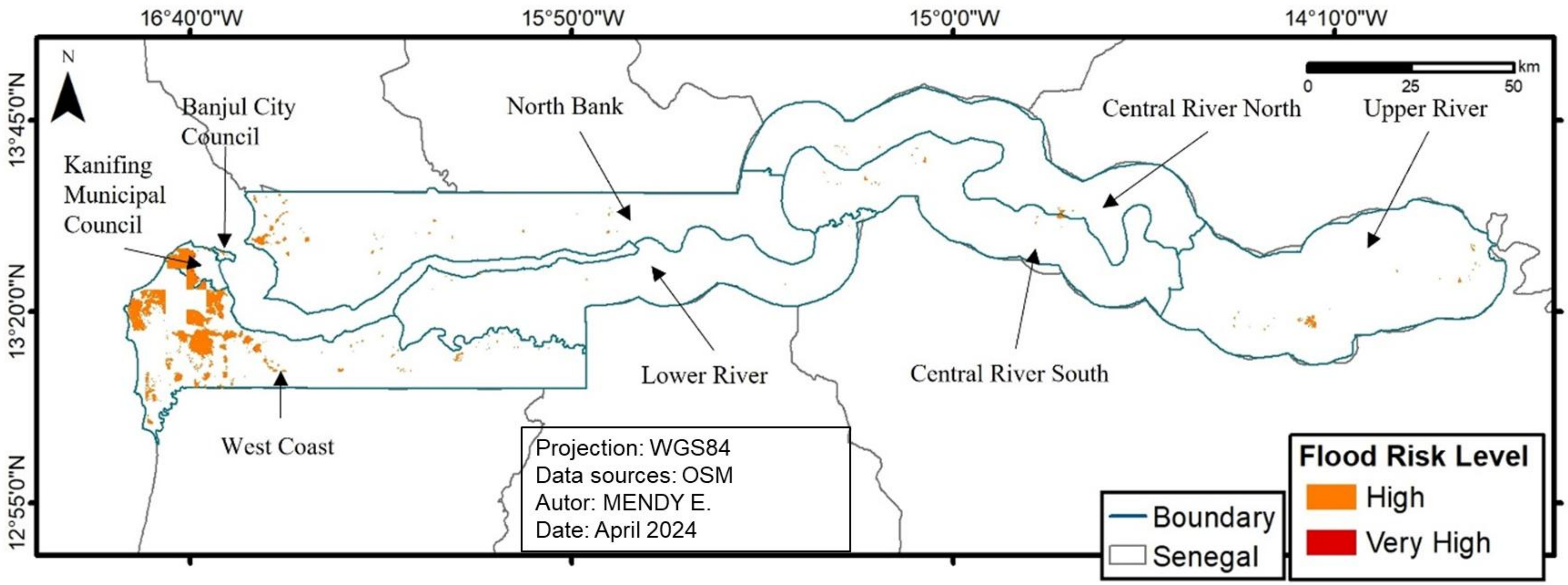


Figure 30: Flood risk map of high and very high-risk level areas with overlaid built area from land use/land cover data

__Table 11: Distribution of flood risk level per areas with overlaid built area from land use/land cover data__

No.	Province/municipal	Level	Area Flood Risk (km^2)
1	Banjul City Council	Very Low	0.00
		Low	0.00
		Moderate	0.00
		High	0.81
		Very High	0.08
2	Central River North	Very Low	1.75
		Low	9.34
		Moderate	10.77
		High	1.70
		Very High	0.00
3	Central River South	Very Low	0.27
		Low	24.63
		Moderate	5.36
		High	3.96
		Very High	0.00
4	Kanifing Municipal Council	Very Low	0.00
		Low	0.00
		Moderate	1.88
		High	32.37
		Very High	0.62
5	Lower River	Very Low	1.12
		Low	20.49
		Moderate	8.52
		High	1.00
		Very High	0.00
6	North Bank	Very Low	10.30
		Low	29.06
		Moderate	15.67
		High	16.62
		Very High	0.00
7	Upper River	Very Low	2.82
		Low	9.57
		Moderate	22.41
		High	8.20
		Very High	0.00
8	West Coast	Very Low	0.00
		Low	2.49
		Moderate	180.09
		High	181.57
		Very High	0.61
Total (km^2)			604.09

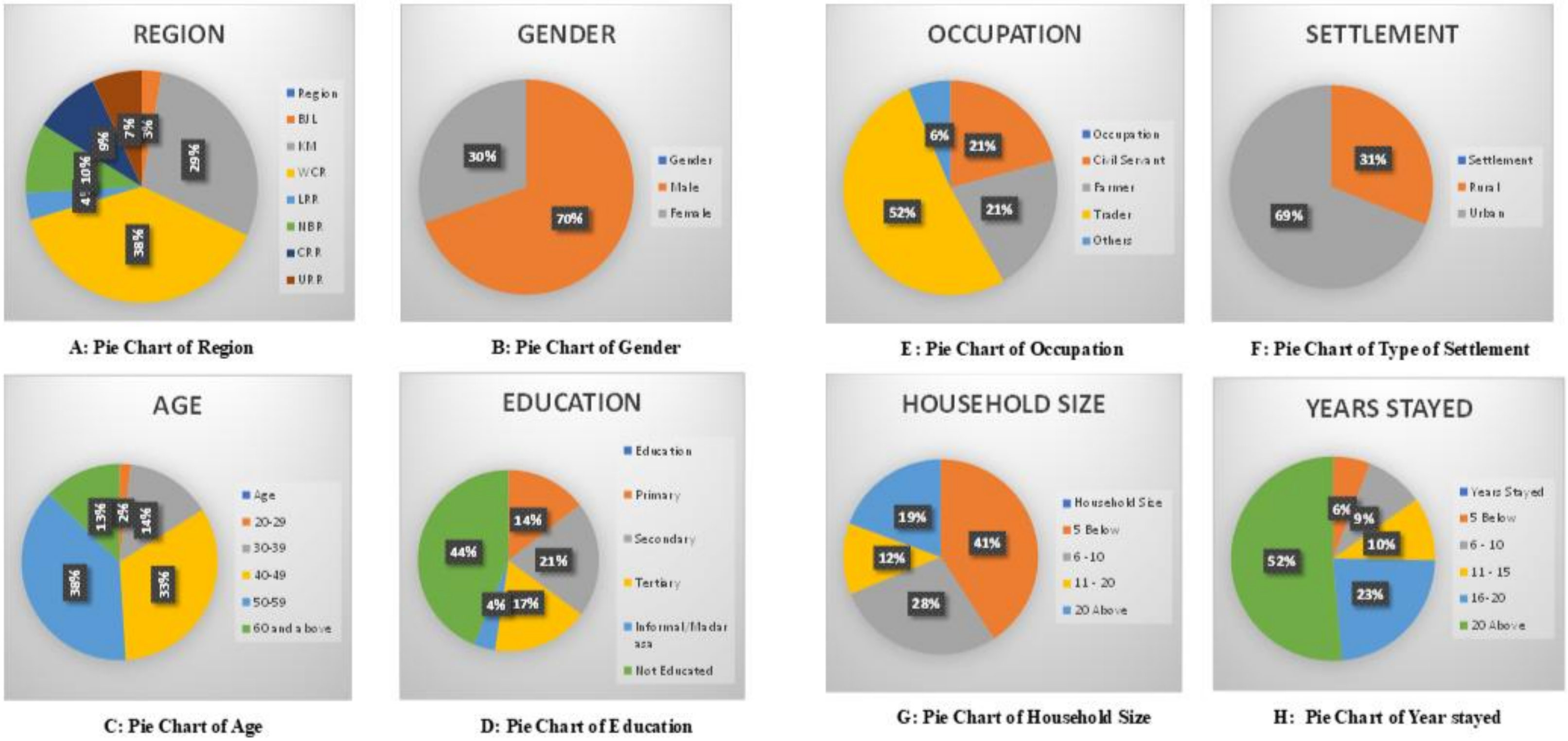
Table 11 presents the distribution of flood risk levels across various provinces and municipalities in The Gambia, measured in square kilometers. The data highlights the extent of flood-prone areas within each administrative region, categorizing them from very low to very high flood risk levels.

The levels of risk for elements within this study area vary significantly, with the western and partially central parts of The Gambia identified as the most severely affected regions. Sub-districts within the study area exhibit differing degrees of flood risk, primarily attributable to diverse environmental characteristics. The study findings suggest that areas characterised by dense settlements and lower elevations face a heightened risk of flooding. Consequently, regions such as WCR, KM, and Banjul (Table 11) are at high risk of flooding due to these combined factors. This observation aligns with the findings of (Hagos *et al*., 2022), who identified factors such as unpredictable drainage patterns, rapidly evolving topography, and limited ground surface infiltration capacity as contributors to increased flood risk. While flooding is a natural phenomenon, human land-use practices often involve the removal of natural vegetation for agricultural or construction purposes, which can significantly increase surface runoff and elevate the risk of both flash floods and river inundations.

SECTION 3: Objective 3. To assess the flood impacts on the communities along the Gambia River

4.3.1 Socio-demographic characteristics of the household head of communities along the River Gambia. The word “data” is plural, not singular.

A total of 422 households responded to this research. Among the respondents, 294 (70%) were males, while 128 (30%) were females. More than one-third, 183 (44%) of the respondents are uneducated, and 88 (21%) are farmers. More than half, 218 (51%) of the respondents, have lived in their communities for more than 20 years. Regarding household size, 250 (59%) have a household size of 6 or above See figure 31.



A: Pie Chart of Region

B: Pie Chart of Gender

E: Pie Chart of Occupation

F: Pie Chart of Type of Settlement

C: Pie Chart of Age

D: Pie Chart of Education

G: Pie Chart of Household Size

H: Pie Chart of Year stayed

Figure 31: Demography of household Heads of communities along the River Gambia

NOTE: This figure presents the demographic and socio-economic characteristics of respondents, including regional distribution, gender, age, education, occupation, settlement type, household size, and duration of residence.

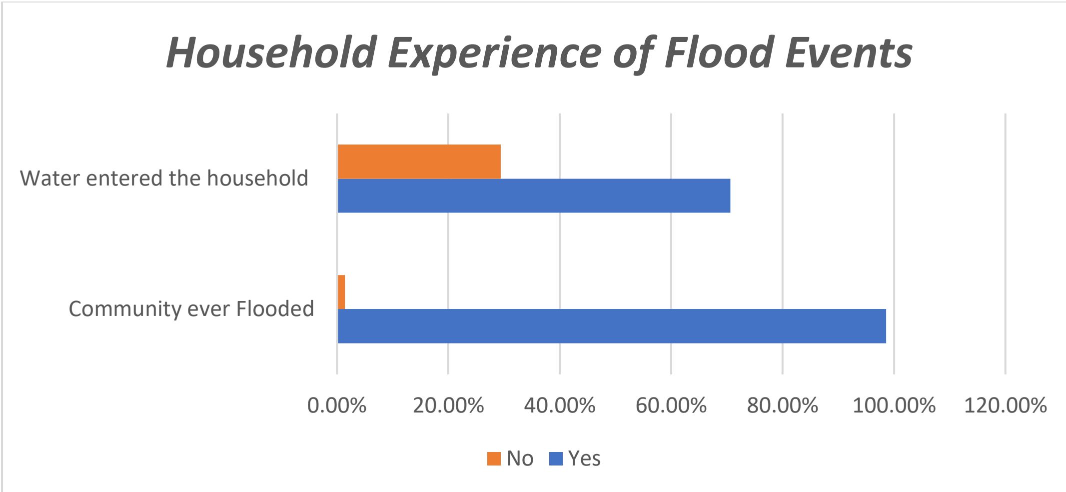


Figure 32: is a cluster bar of Household Experience of Flood Events

Household experience of flood events shows that 416 (98.6%) had experienced a flood in their community. 298 (70.6%) stated that their houses had experienced floods where water entered their buildings as shown in figure 32.

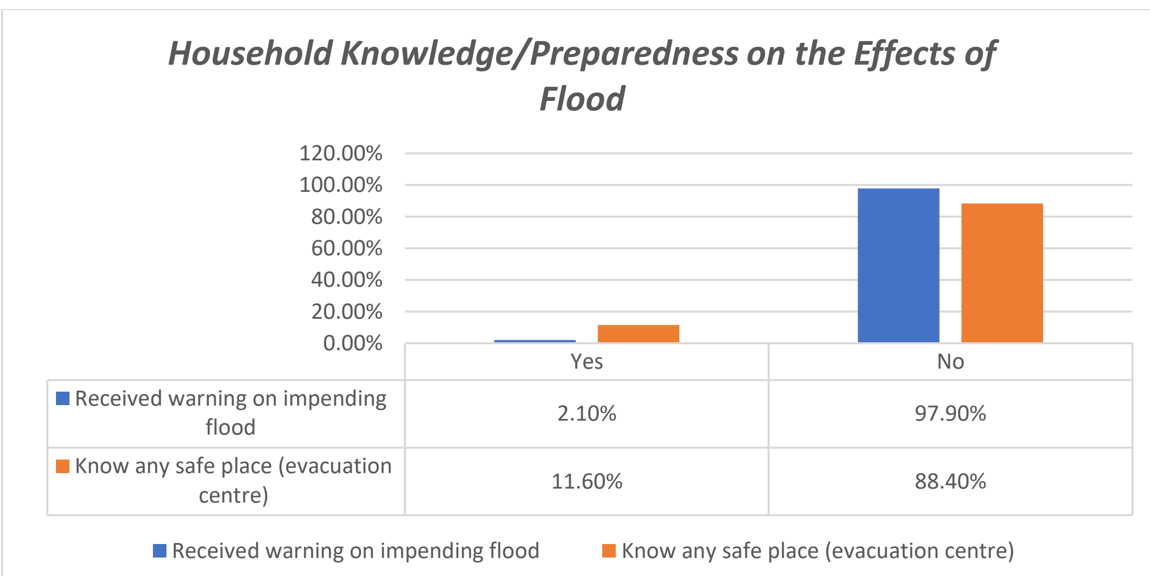


Figure 33: is a cluster column chart showing Household Knowledge/Preparedness on the Effects of Flood

The result shows that the local people have less information about the impending floods, out of the respondents 9 (2.1%) said that they have information about the impending floods. 373 (88.4%) of the respondents said that they did not know any evacuation center during flood disasters figure 33.

The result of household knowledge or preparedness on the effects of the flood figure 33 shows that the majority of the local people have knowledge of flood events but are not fully informed and prepared for early warning. This is in agreement with the research carried out by Perera *et al*. (2019), which reveals that the local people do not have an adequate response to an early warning system to reduce the effect of flood disasters. In the same vein, a similar survey was carried out in Pakistan, and the result suggested that there was an ineffective early flood warning system that could be a result of many factors (Samansiri *et al*., 2023). In addition, the result of this research has shown that the majority of the local people could not identify locally, a designated location or place for an evacuation centre during a flood disaster, contrary to what was found in the research conducted in Indonesia; (Sutton *et al*., *et al*., 2020; Rahman *et al*., 2018).

4.3.2. Impacts of flood on households along the River Gambia using Pearson Chi-square test

Table 12 shows Pearson Chi-square results for the impacts of the flood on households along the River Gambia. In the results, region and gender were highly significantly associated with the impact of death due to floods. The region, gender, ethnic group, and occupation were also highly significantly associated with the impact of the flood on injury to household members. Region, gender, age, ethnic group, occupation, settlement type, household size, and number of years stayed in the community were all highly significantly associated with the impact of water entering houses.

Table 12: Pearson chi-square result for the impact of the flood on household

Items	Factors	X Value	P Value
Did any member of your household die as a result of the last flood?	Region	29.882	.000
	Gender	9.275	.002
	Age	2.774	.596
	Ethnic Group	4.116	.249
	Religion	.411	.521
	Marital Status	.395	.983
	Education Level	4.746	.314
	Occupation	7.341	.062
	Settlement Type	3.645	.056
	Household Size	5.384	.146
	Years in the community	3.779	.437
Did any member of your household suffer injury as a result of the last flood?	Region	51.466	.000
	Gender	19.742	.000
	Age	9.501	.050
	Ethnic Group	14.862	.002
	Religion	2.363	.124
	Marital Status	8.768	.067
	Education Level	5.394	.249
	Occupation	23.648	.000
	Settlement Type	1.055	.304
	Household Size	3.353	.340
	Years in the community	3.632	.458
Do you consider your coping strategies sufficient?	Region	2.055	.915
	Gender	1.758	.185
	Age	51.863	.000
	Ethnic Group	2.485	.478
	Religion	.411	.521
	Marital Status	27.772	.000
	Education Level	27.486	.000
	Occupation	13.686	.003
	Settlement Type	1.818	.178
	Household Size	4.768	.190
	Years in the community	8.840	.065
Did water enter your building during the last flood?	Region	92.407	.000
	Gender	14.913	.000
	Age	10.685	.030
	Ethnic Group	12.079	.007
	Religion	.290	.590
	Marital Status	8.545	.074

	Education Level	9.078	.059
	Occupation	16.671	.001
	Settlement Type	43.355	.000
	Household Size	22.826	.000
	Years in the community	29.147	.000
Has your community ever been flooded?	Region	13.797	.032
	Gender	1.114	.291
	Age	4.611	.330
	Ethnic Group	12.727	.005
	Religion	.620	.431
	Marital Status	.578	.966
	Education Level	2.464	.651
	Occupation	3.324	.344
	Settlement Type	3.608	.057
	Household Size	4.578	.205
	Years in the community	5.945	.203

Table 12 presents statistical analyses of various factors (region, gender, age, ethnic group, etc.) in relation to different flood-related impacts and experiences. The X values represent the test statistics, while the P values indicate the significance level of each factor's association with specific outcomes, such as death, injury, coping strategies, and household flooding.

Pearson chi-square result for households' preparedness for flood risk indicated that region, age, ethnic group, marital status, educational level, occupation, settlement type, household size, and years in the community were all statistically significantly associated with the household preparedness toward flood events. This is similar to the research carried out by Elum *et al*. (2022), where their Pearson chi-square shows age and household size have an influence on the preparedness of local people for the flood. The chi-square analysis test (Table 12) shows that region, gender, ethnic group, and occupation were the only demographic variables that have shown a statistically significant association with the question about death as an impact of flood in their communities. Furthermore, region, gender, age, ethnic group, occupation, settlement type, household size, and number of years stayed in the community were all highly significantly associated with the impact of water entering the house and its consequences. This suggested that local people know and are aware of the impact of floods in their communities. A similar research carried out by Rakib *et al*. (2017) indicated that the local people (80%) are aware of the flood impacts or consequences.

4.3.3 Households' preparedness to flood risk along the River Gambia using Pearson Chi-square test

Table 13 shows Pearson chi-square results of households' preparedness to flood communities along the River Gambia. Region, age, ethnic group, religion, education level, settlement type, household size, and years in the community were all significantly associated with household access to electricity. Region, age, ethnic group, religion, educational level, occupation, settlement type, household size, and years in the community were all significantly associated with household members having health or asset insurance in case of flood disaster. Region, age, ethnic group, marital status, educational level, occupation, settlement type, household size, and years in the community were all highly significantly associated with household preparedness for flood events.

This study also tried to find out whether the local people had been interacting with flood risk maps but the majority of the respondents said that they did not have flood maps. A similar research was carried out in Ethiopia and it was established that flood risk maps were of great help in local coping strategies in flood management (Worku, and De- Paola, 2018).

Table 13: Pearson chi-square results for households' preparedness for flood risk

Items	Factors	XValue	PValue
Does your household have access to electricity?	Region	40.458[a]	.000
	Gender	3.229[a]	.072
	Age	12.133	.016
	Ethnic Group	32.848	.000
	Religion	88.921	.000
	Marital Status	5.838	.212
	Education Level	21.044	.000
	Occupation	108.153	.000
	Settlement Type	30.710	.000
	Household Size	15.616	.001
	Years in the community	56.400	.000
Do you have access to flood maps?	Region	13.256	.039
	Gender	.010	.919
	Age	31.501	.000
	Ethnic Group	3.148	.369
	Religion	.725	.395
	Marital Status	15.357	.004
	Education Level	6.611	.158
	Occupation	11.020	.012
	Settlement Type	5.424	.020
	Household Size	10.774	.013
	Years in the community	9.445	.051
Have you used any institution to insure yourselves (life, health) or property (household goods, house vehicle, and the like) in the past 12 months?	Region	69.634	.000
	Gender	.015	.904
	Age	23.038	.000
	Ethnic Group	33.319	.000
	Religion	11.835	.001
	Marital Status	4.121	.390
	Education Level	19.328	.001
	Occupation	29.914	.000
	Settlement Type	8.957	.003
	Household Size	15.792	.001

	Years in the community	12.783	.012
Does your household know of any safe place (Evacuation centre) you could move to during flood events?	Region	46.314	.000
	Gender	9.123	.003
	Age	7.472	.113
	Ethnic Group	19.589	.000
	Religion	5.504	.019
	Marital Status	8.362	.079
	Education Level	38.819	.000
	Occupation	24.586	.000
	Settlement Type	4.161	.041
	Household Size	3.748	.290
	Years in the community	33.178	.000
Are there preparations your household makes beforehand in anticipation of the flood?	Region	21.084	.002
	Gender	.144	.705
	Age	46.138	.000
	Ethnic Group	39.847	.000
	Religion	.010	.919
	Marital Status	79.628	.000
	Education Level	55.695	.000
	Occupation	41.169	.000
	Settlement Type	8.430	.004
	Household Size	19.870	.000
	Years in the community	11.370	.023

Table 13 presents statistical analyses of factors influencing households' preparedness for flood risk access. The X values represent the test statistics, while the P values show the significance of the association between each factor (region, gender, age, ethnic group, etc.) and various household flood-related practices and resources.

4.3.4 Local communities' knowledge of their local coping strategies

Table **14**. shows the binary logistic result of how the local people responded to their flood local coping strategies. The result reveals that KM (CL 9.250-3.739 and p= .000), NBR (CL-1.038-4.824 and p= .002) and CRR (CL3.535-0.141 and p= .034), male gender (CL -0.303-3.014 and p= .016), household head youth age 20-29 (CL 11.669-1.553 and p= .010), Mandinka ethnic group (CL 3.557-0.782 and p= .002), informal education (CL -0.945-4.270 and p= .002), rural settlement type (CL 0.042-4.377 and p= .055), household size 5 below (CL 4.224-0.416 and p= .017), 6-10 (CL 4.545-1.519 and p= .000) and 11-20 (CL 6.120-2.764 and p=.000), and number of years stayed in the community 6-10 (CL7.909-0.089 and P= .045) and 16-20 (CL 2.283-0.123 and p=

.029) were all significantly associated with the household heads' knowledge on their local coping strategies.

Table 14: The binary logistic result on how local communities' members viewed their coping strategies was sufficient: Positive knowledge of local coping strategies

Variables	Odd ration	(95% CL)	P value
Region			
BJL	2.4444	6.065-1.176	.186
KM	6.495	9.250-3.739	.000
WCR	1.653	3.414-0.108	.066
LRR	1.767	3.670-0.136	.069
NBR	-2.931	-1.038-4.824	.002
CRR	1.838	3.535-0.141	.034
URR	Ref	ref	ref
Gender			
Male	-1.659	-0.303-3.014	.016
Female	ref	ref	ref
Age			
20-29	6.611	11.669-1.553	.010
30-39	-1.720	0.452-3.892	.121
40-49	-0.750	0.820-2.320	.349
50-59	-0.960	0.573-2.494	.220
60 and above	ref	ref	ref
Ethnic Group			
Mandinka	2.169	3.557-0.782	.002
Wolof	0.607	2.969-1.756	.615
Fula	1.236	2.753-0.282	.111
Others	ref	ref	ref
Religion			
Islam	-0.369	1.419-2.156	.686
Christianity	ref	ref	ref
Marital Status			
Married	20.855	155749.472-155707.762	1.000
Single	15.478	155744.095-155713.139	1.000
Widowed	119.267	155748.175-155709.059	1.000
Divorced	Ref		Ref
Education			
Primary	0.995	2.251-0.260	.120

Secondary	-0.407	1.044-1.858	.582
Tertiary/University	-0.427	1.120-1.975	.588
Informal/ Madarasa	-2.607	-0.945-4.270	.002
NA	ref	ref	ref
Occupation			
Civil Servant	1.873	4.792-1.045	.208
Farmer	1.981	4.736-0.775	.159
Trader	-1.884	0.704-4.473	.154
Others	ref	ref	ref
Settlement Type			
Rural	-2.168	0.042-4.377	.055
Urban	ref	ref	ref
Household Size			
5 below	2.320	4.224-0.416	.017
6-10	3.032	4.545-1.519	.000
11-20	4.442	6.120-2.764	.000
20 and above	ref	ref	ref
Years stayed in the community			
5 below	20.240	27231.607-27191.127	.999
6-10	3.999	7.909-0.089	.045
11-15	-0.724	0.758-2.207	.338
16-20	1.203	2.283-0.123	.029
20 and above	ref	ref	ref

Note: Table 14 presents the odds ratios (OR), 95% confidence intervals (CI), and p-values for various factors associated with flood-related outcomes. Regions such as KM (p < 0.001) and NBR (p = 0.002) show significant associations with the outcomes, while factors like gender, marital status, and religion show less significant associations.

4.3.5 Qualitative data: Knowledge of flood among the local communities during FGD

Participants showed local knowledge of flood management. All participants pointed out that both river and flash floods occurred mainly during the rainy season (June to October). They pointed out that whilst flooding can be induced by heavy rainfall, it frequently happens where there is less preparation and socioeconomic strength to curb the effect of flood.

"… *yes rainfall is the main cause of flood in this community, but our way of settlement and financial strength are not able to handle the effect of the flood as you can see*…." (Participant 2 in Darsimaleh -Male group).

The participants said that water spread rapidly in their villages due to the intensity and duration of rainfall. The longer the rainfall, the faster the flood water will flood and the more destruction it will cause on farmlands and buildings. Based on this, women in LRR were able to identify a particular place in the village square, a high land which they viewed as a temporary evacuation centre during severe floods. Moreover, the men group in CRR-North showed a very high level of awareness of vulnerability and exposure to certain locations in their villages; they've reiterated that households located in swampy (lowland) mud houses and are not raised higher above the ground are the ones mostly affected during flood events.

4.3.6 The impact of flood -FGD

It was unanimously agreed in all the discussions that the greatly and frequently affected asset is their farmlands. However, roads are the second most destroyed as mentioned by the majority. Buildings came third hence some participants said that their houses were not seriously affected because they built them on high land instead of lowland.

The impact of the flood in The Gambia is intensely felt, as much research has shown in other parts of the world where floods, in some cases, claimed lives. (Olanrewaju *et al*., 2019); (Hu *et al*., 2018), in their research, noticed that the impact did not only stop at destroying roads and buildings but also on vulnerable lives with very low resilience. Runoffs, coverage areas, and impacts of the flood are on the increase, as stated by the participants in FGD. Most of the informants have a view that the main cause of flood could be anthropogenic activities like blocking the drainage system, building houses or fences on the runoff, building flimsy house foundations, etc. Similar causes were also identified in research carried out in Nigeria (Aderogba, 2012). In addition, this research also reveals that floods are capable of destroying people's assets like farmlands, buildings, roads, livestock, etc. This is also mentioned by Aderogba (2012); Banerjee (2010); Banerjee (2010) in their research on the effect/impact of floods on the people.

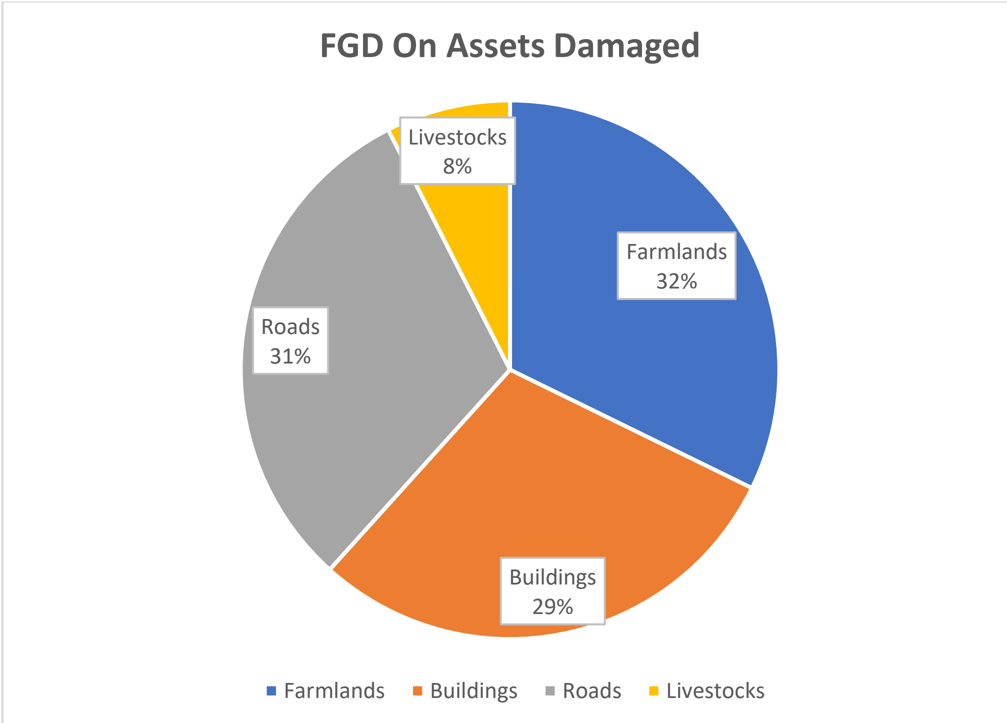


Figure 34: A bar chart showing the response of participants of FGD in the five regions on assets damaged

Based on the FGD, participants showed that floods have a great impact on their livelihoods. Out of the total participant who said 'yes', a flood has damaged their assets; Figure 34 shows that farmlands (32%) and roads (31%) are the two most affected assets out of the four assets discussed. Out of the 70 participants in the five regions during the FGD, 69 participants agreed that their farmlands were destroyed by flood, 63 out of 70 agreed that their buildings were destroyed, 66 out of 70 also said that the roads were destroyed, 16 out of 70 said that their livestock were destroyed by flood water. "…. *We are always seeking help both from the government and philanthropists to prevent our farms from flooding because we are financially constrained*." (FGD Male group NBR). Even though local people have some local strategies for coping with floods, they all admitted that their strategies are not sufficient; thus, they needed help to be able to manage the adverse effects of floods in their communities properly. "….. *yes we have our local means of managing flood, but we are very often overwhelmed by the strength the flood water enters our farmlands and houses; that is why we need help to be able to do our farming well, especially during the rainy season*" (FGD, Female group LRR).

Table 15: Showing the local people's flood coping strategies during FGD

Local Strategy	Explanation
Sandbag	Filling sandbags and placing them on the runoff waterway. This helps to reduce the speed and the force of water especially flood water entering the house.
Raised elevations of the house	Raising the elevation of the house high above the ground level. This helps the house to be above the flood water level thus minimising the entering of water into houses during flood events.
Construction of contour bonds and dikes	Constructing contour bonds helps block and divert flood water and has been seen as a very effective and helpful coping strategy among the local people.
Building houses on highland	Building houses on highlands had been seen by many to be very effective. Local people survey the land before they decide to construct their houses on the site.

This research revealed that households always employ local coping strategies. Local strategies like sandbags to block or reduce the speed of flood water, household reinforced buildings or raised elevations of the house to obstruct the entry of flood waters into their houses, and constructing contour bonds and dikes to prevent flood were all identified during the research which was in consonant with the research carried out by Yin *et al*. (2021) and Jonga *et al*. (2021). Based on the result (Table 15), the local community members had much more concentration on the control of flood water and their assets than on the control of flood water sources (Iacob *et al*., 2014).

SECTION 4: Objective 4: To examine the perception of local people on the effect of climate change

4.4.1 Socio-demographic characteristics of the local people along the River Gambia

Figure 35 shows that the majority of the respondents (80.81%) did not experience extreme weather (temperature), while a minority of the respondents attested to the experience of extreme temperature. This result suggests that only some people in the study area have been exposed to extreme temperatures compared to flooding.

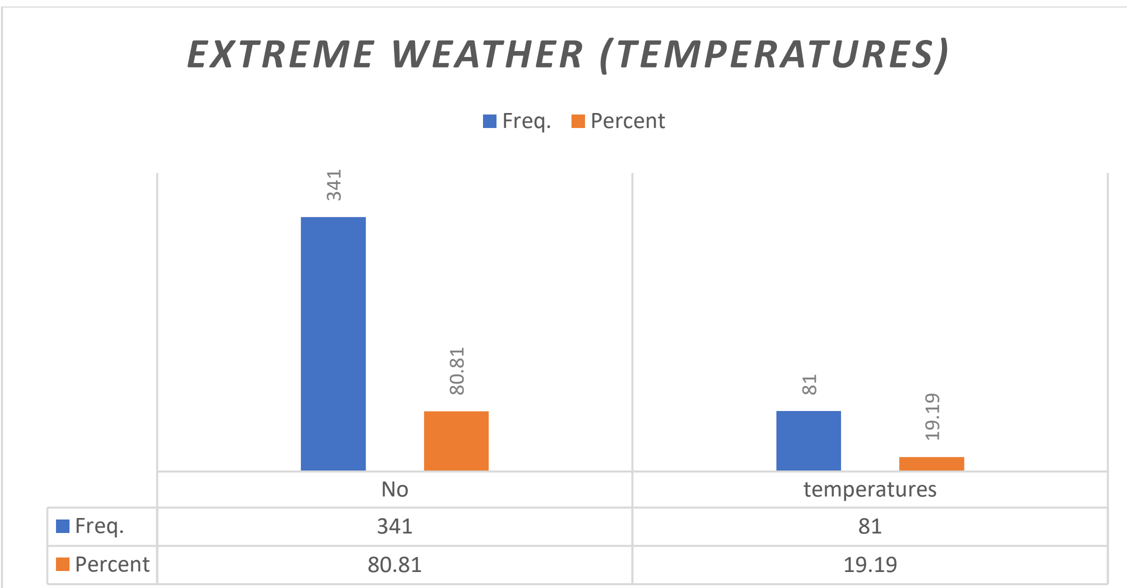


Figure 35: shows a clustered chart of respondents experience of extreme temperature

Figure 36 shows a very strong knowledge of the respondents on flood as an extreme weather event where 98.6% claim to have experienced flooding and 1.4% mentioned that they did not experience flooding. Based on the result, flooding appears to be a great concern in the study area affecting more than 90% of the inhabitants.

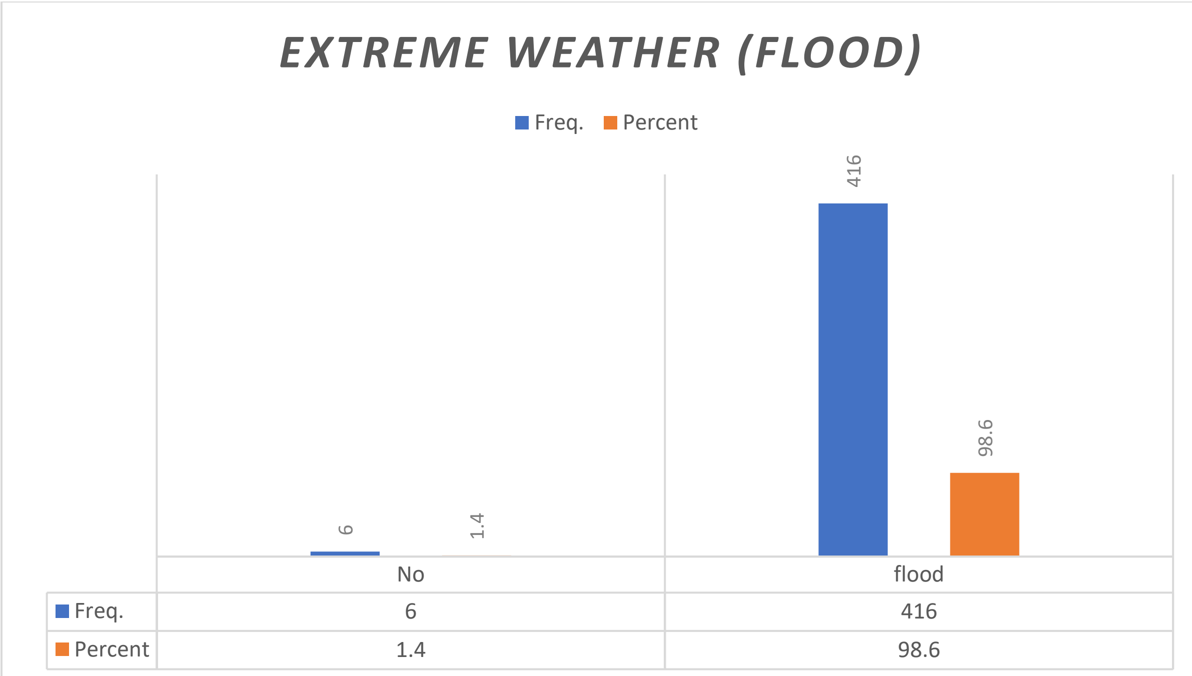


Figure 36: shows a clustered chart of respondents' experience of extreme flood

Figure 37 shows that 13.27% of the respondents claimed to have experienced drought, whereas 86.73% said that they did not experience severe drought compared to frequent flooding. Unlike flooding, drought is a lees concern among the affected population because it is affecting a smaller population of the study area.

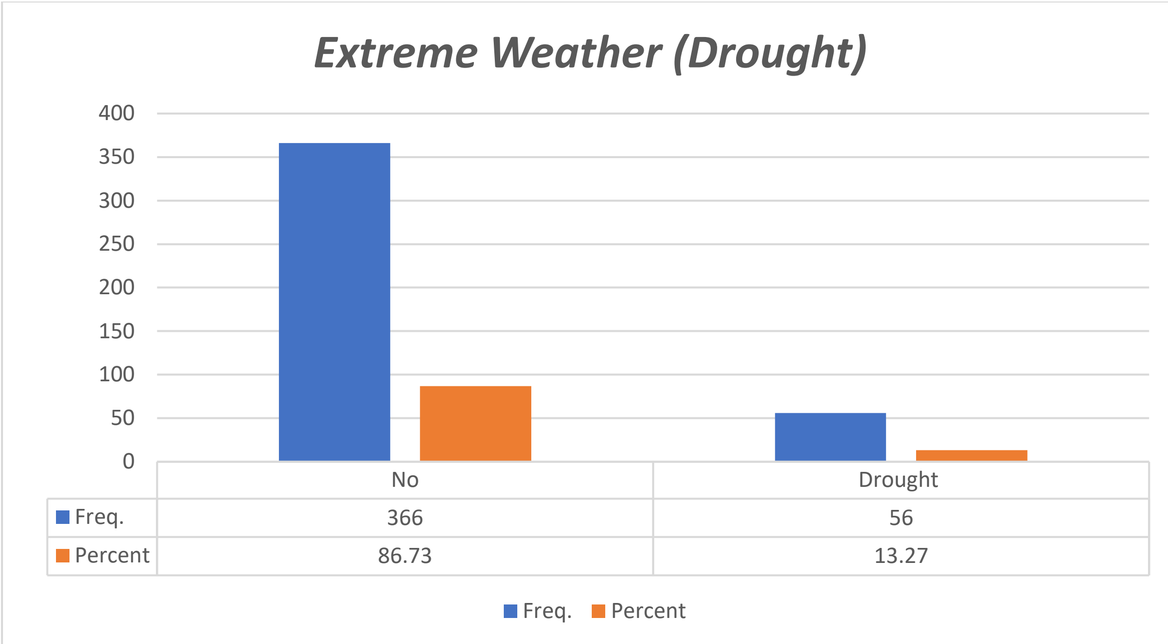


Figure 37: shows a clustered chart of respondents' experience of extreme drought

The result in figure 38 shows that the majority of the respondents are urban settlers (68.96%) and 31.04% are reportedly to be rural dwellers. This indicated a strong rural-urban migration in The Gambia as the distribution of the questionnaires was based on the population size of each region.

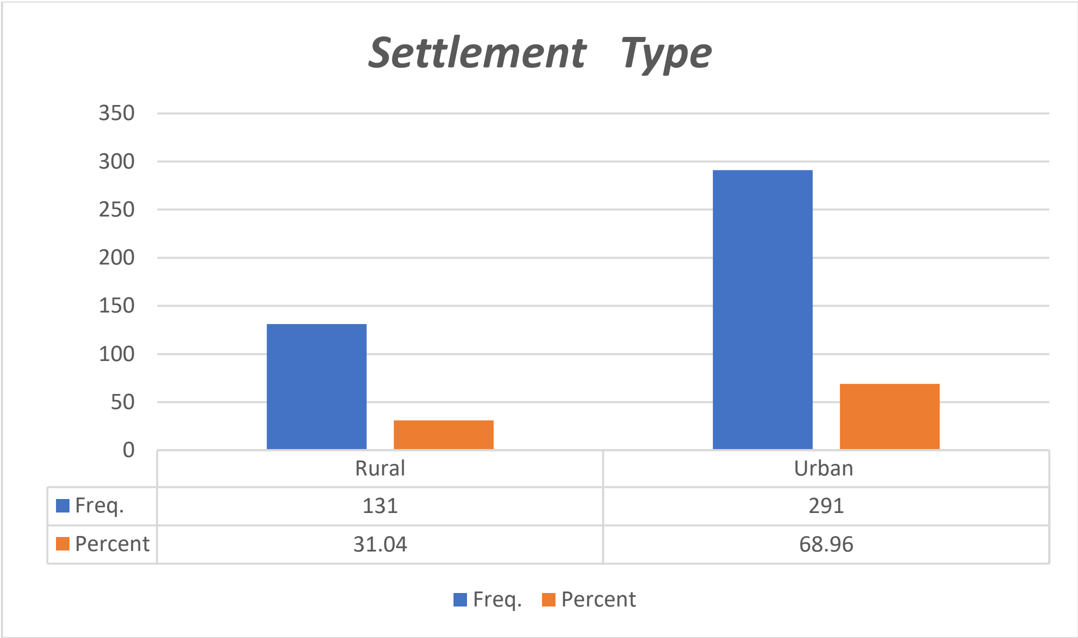


Figure 38: shows a clustered chart of respondents' settlement type

4.4.2 Perception of Damages

There is a high agricultural loss, as shown in figure 39, where 90.05% of the respondents claimed to experience agricultural loss, and 9.95 said they did not experience it. This suggests that those who have agriculture as their livelihood a more vulnerable to climate variation shocks as it is affecting a majority of the people in The Gambia. As agriculture is the main primary source of the local people's income, this lost is having a serious economic and food security challenge in The Gambia.

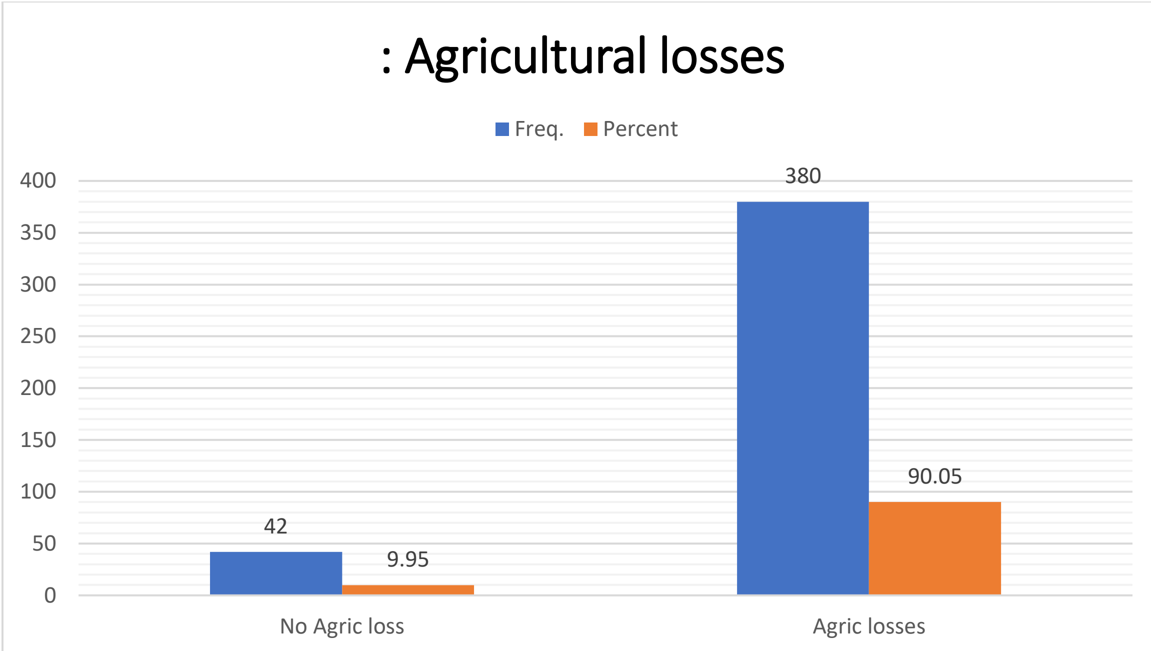


Figure 39: shows a clustered chart of respondents' response on agricultural lost during flooding

Note: the majority of the population experienced agricultural losses due to climate shocks, around 90% of the population.

A few respondents (9.72.%) mentioned that they had lost their livestock during flooding figure 40. Even though the number of respondents who experienced this lost is small, the impact on their economic could be felt by the few affected as livestock could be their main source of income.

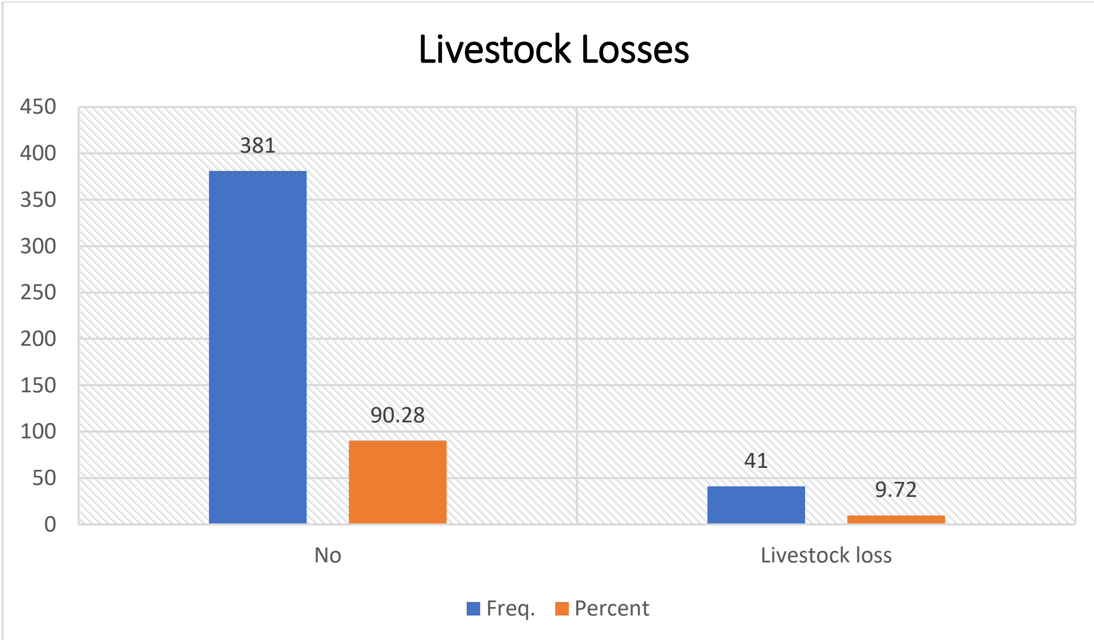


Figure 40: shows a clustered chart of respondents' response on livestock lost during flooding

4.4.3 Climate Change Perception Index

Table 16 shows a perception score index where the mean perception score is 40.6 (on a scale of 0 to 100), with a standard deviation of 34.23. the range score varies widely from 0 to 100, showing diverse levels of climate change awareness within the study population. Based on this, the average score suggests a moderate level of climate change perception. Notwithstanding, the high standard deviation points to very significant variability, meaning that while some respondents are highly aware, some have little or no perception of climate change.

Table 16: Perception index

Variable	Obs	Mean	Std. dev.	Min	Max
Perception score	413	40.5973	34.22698	0	100

The perception index categorisation in figure 41 shows that a significant portion of the population (over 64%) has a low or very low perception of climate change. In contrast, only about 35% have high or very high perceptions. This distribution suggests that efforts to raise awareness and understanding of climate change may be necessary, particularly in communities where perception is low.

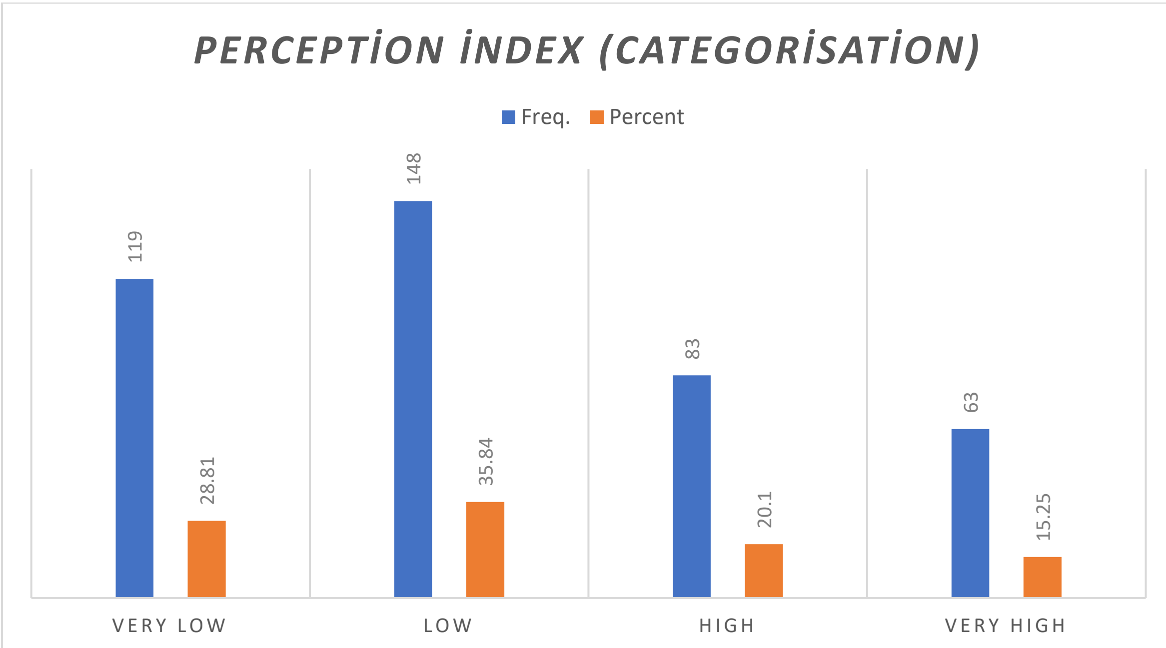


Figure 41: shows a clustered chart of the perception index categorisation

The figure shows the perception index was normalised to 100. A value of zero indicates the absence of climate change perception, while a value of 100 indicates a higher climate change perception. The average perception score was 40.6 over 100, indicating a moderate climate change perception among the population (Table 16). More so, 29% of the population has a very low climate change perception, while 15% has a very high climate change perception as seen in Figure 42.

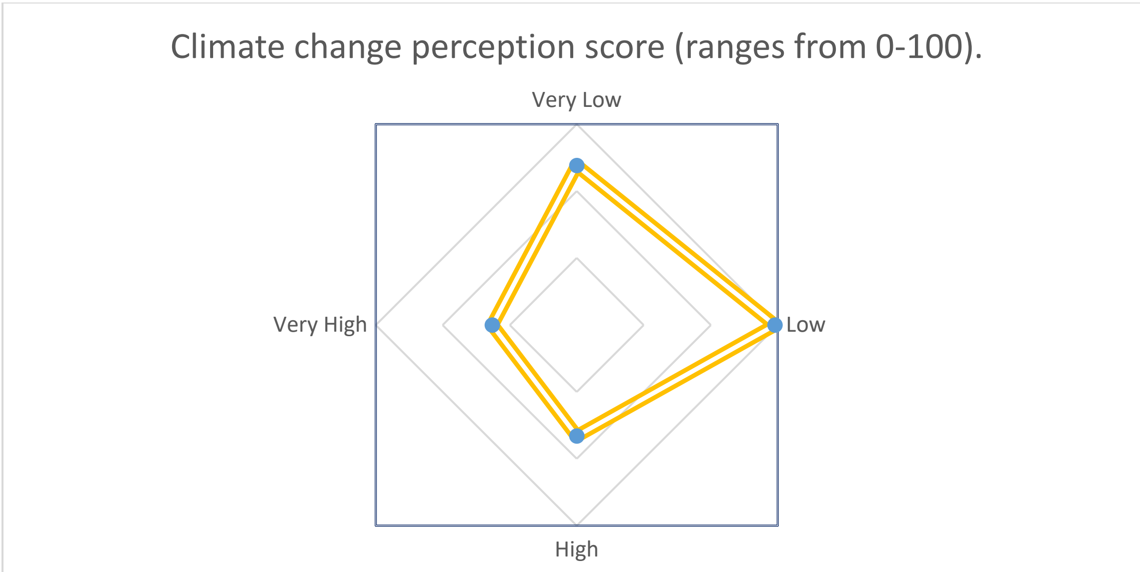


Figure 42: Climate change perception score (ranges from 0- 100)

Table 17 shows a very significant variation in climate change perception based on type of settlement, gender, age, ethnicity, religion, marital status, education, and occupation of respondents. Those rural dwellers predominantly show a very low perception of climate change (50%), while urban dwellers have a more balanced distribution of perception (very low (19.3%; low 37.2%; high 23%; very high 19.6%). In the same vein, women demonstrated a higher perception of climate change, 26.4%, than men, 10.6%. This pattern of perception differences is also observed across other categories, such as education, where individuals with higher education levels tend to have a higher climate change perception.

Table 17: Climate change perception by population characteristics

	Climate change perception index				
	Very Low	**Low**	**High**	**Very High**	**Total**
	%	%	%	%	%
Settlement					
Rural	50	32.8	11.7	5.5	100
Urban	19.3	37.2	23.9	19.6	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(3) = 47.4910 Pr = 0.000					
Gender					
Male	34.6	39	15.8	10.6	100
Female	14.9	28.1	30.6	26.4	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(3) = 37.8054 Pr = 0.000					
Age					
20- 29	12.5	12.5	75	0	100
30- 39	12.1	70.7	5.2	12.1	100
40- 49	29.9	35.8	22.6	11.7	100
50- 59	31.2	29.3	19.7	19.7	100
60 and above	39.6	20.8	22.6	17	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(12) = 58.9953 Pr = 0.000					
Ethnic Group					
Mandinka	25.6	38.4	20.2	15.8	100
Wolof	35.3	5.9	5.9	52.9	100
Fula	40.8	31.6	14.3	13.3	100
Others	22.1	40	28.4	9.5	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(9) = 37.7610 Pr = 0.000					
Religion					
Islam	29.1	37.7	18.4	14.7	100
Christianity	25.6	17.9	35.9	20.5	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(3) = 10.1262 Pr = 0.018					
Marital Status					
Married	30.2	33.1	19.3	17.4	100
Single	42.9	14.3	42.9	0	100
Widowed	18.7	45.3	22.7	13.3	100
Divorced	33.3	61.1	5.6	0	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(12) = 25.7695 Pr = 0.012					

Education					
Primary	24.6	19.3	43.9	12.3	100
Secondary	23	52.9	16.1	8	100
Tertiary/University	28.2	12.7	22.5	36.6	100
Informal/Madarasa	56.3	43.8	0	0	100
Not Available	30.8	41.2	15.4	12.6	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(12) = 79.5293 Pr = 0.000					
Occupation					
Civil Servant	25.9	18.8	24.7	30.6	100
Farmer	44.3	31.8	18.2	5.7	100
Trader	26.3	46.5	17.4	9.9	100
Others	7.4	18.5	33.3	40.7	100
Total	28.8	35.8	20.1	15.3	100
Pearson chi2(9) = 66.7634 Pr = 0.000					

Note: Table 17 indicates that 26.4% of women have a very high perception of climate change, while only 10.6% of men perceive a very high perception of climate change.

4.4.4 The effect/impact of climate change on the local community

Results outlined in Table 18 reveal that drought and floods increase the risk of agricultural losses, with a greater risk associated with drought. Notably, populations experiencing drought have a risk of agricultural losses 181 times higher than those who don't. Similarly, populations experiencing floods have a risk of agricultural losses 8 times higher than those who don't. Additionally, factors such as religion, household size, and education level significantly affect the likelihood of agricultural losses.

Table 18: Results of Logistic regression of the impact of climate change on agricultural

Agric_damages	**Odds ratio.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
drought	181.555	272.84	3.46	.001	9.546	3452.956	***
flood	8.362	5.824	3.05	.002	2.135	32.748	***
Settlement	3.488	3.409	1.28	.201	.514	23.69	
Gender	.285	.171	-2.09	.036	.088	.923	**
Age	.987	.278	-0.05	.962	.568	1.714	
EthnicGrp	1.59	.466	1.58	.114	.895	2.824	
Religion	.039	.042	-3.02	.003	.005	.32	***
MStatus	1.85	.652	1.75	.081	.927	3.691	*
Education	1.701	.387	2.34	.02	1.089	2.657	**
Occupation	1.114	.306	0.39	.694	.651	1.907	
HHSize	3.298	1.423	2.77	.006	1.416	7.681	***
Wall_Made	1.339	.391	1.00	.317	.756	2.374	
Roof_Made	.594	.58	-0.53	.594	.088	4.03	
Floor_Made	.169	.077	-3.90	0	.069	.412	***
Access_Electric	.623	.728	-0.40	.685	.063	6.162	
Use_Radio	1.039	.714	0.06	.956	.27	3.999	
Use_TV	1.257	1.063	0.27	.787	.239	6.599	
Internet	1.149	.955	0.17	.867	.226	5.858	
Constant	7.6	23.075	0.67	.504	.02	2918.311	

Mean dependent var	0.900	SD dependent var	0.300
Pseudo r-squared	0.442	Number of obs	422
Chi-square	120.746	Prob > chi2	0.000
Akaike crit. (AIC)	190.744	Bayesian crit. (BIC)	267.599

*** *p<.01*, ** *p<.05*, * *p<.1*

Note: Table 18 presents the results of the logistic regression analysis for agricultural damages where significant predictors (p < 0.05) include drought, flood, gender, religion, education, household size, and floor material, with the respective p-values marked accordingly.

Results outlined in Table 19 reveal that drought and floods increase the risk of livestock losses. Notably, populations experiencing drought have a risk of agricultural losses 0.005 times lower than those who don't experience drought. Similarly, populations experiencing floods have a risk of agricultural losses 0.12 times lower than those who don't experience floods. However, socioeconomic factors like gender, religion, household size, and education were all found to be highly significant and also significantly influence the likelihood of experiencing livestock losses.

Table 19: Results of Logistic regression of the impact of climate change on Livestock losses

Live_damages	Odds ratio.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
drought	.005	.008	-3.43	.001	0	.107	***
flood	.119	.083	-3.05	.002	.03	.469	***
Settlement	.293	.293	-1.23	.219	.041	2.074	
Gender	4.165	2.549	2.33	.02	1.255	13.822	**
Age	.996	.28	-0.01	.989	.574	1.729	
EthnicGrp	.63	.186	-1.57	.117	.353	1.123	
Religion	27.861	30.4	3.05	.002	3.283	236.47	***
MStatus	.539	.189	-1.76	.078	.271	1.073	*
Education	.572	.133	-2.41	.016	.363	.901	**
Occupation	.915	.254	-0.32	.748	.531	1.577	
HHSize	.312	.136	-2.68	.007	.133	.732	***
Wall_Made	.713	.214	-1.13	.26	.396	1.284	
Roof_Made	1.655	1.582	0.53	.598	.254	10.771	
Floor_Made	5.622	2.578	3.77	0	2.288	13.811	***
Access_Electric	1.58	1.864	0.39	.698	.156	15.96	
Use_Radio	.883	.619	-0.18	.86	.224	3.489	
Use_TV	.758	.648	-0.32	.746	.142	4.05	
Internet	.868	.729	-0.17	.866	.167	4.502	
Constant	.167	.504	-0.59	.554	0	62.311	

Mean dependent var	0.097	SD dependent var	0.297
Pseudo r-squared	0.444	Number of obs	422
Chi-square	119.418	Prob > chi2	0.000
Akaike crit. (AIC)	187.641	Bayesian crit. (BIC)	264.496

*** *p<.01*, ** *p<.05*, * *p<.1*

Note: Table 19 presents the logistic regression results for the impact of climate change on Livestock losses where significant predictors (p < 0.05) include drought, flood, gender, religion, education, household size, and floor material.

CHAPTER 4:

DISCUSSION

5.0 Demography

The demographic and socioeconomic information highlights the studied populace's vital features, segments, and financial attributes. Flooding is a predominant issue, while other outrageous climate occasions are uncommon. The population in the study communities is transcendently hitched, moderately aged, and knowledgeable in their local knowledge even though the majority (43.8%) of them have not been to formal education, with a huge part living in urban areas, approximately 69%. There is a strong indication of access to electricity, while the population also has access to television and the web, showing great infrastructure and connectivity in The Gambia. To achieve the objective of this thesis, there was not much attention to social dynamics in the selection of respondents. The gender imbalance and the distribution across ethnic and religious groups suggest potential areas for further exploration in terms of social dynamics research.

5.1.0 SECTION 1: Indigenous knowledge of flood hazards in The Gambia

5.1.1 Indigenous Knowledge and Flood Awareness

The result of these findings reveals that there is a strong awareness of flood risks within the local communities along the river Gambia. The importance of IK in disaster risk management is to reflect the value of live experience in localized communities in adaptation to the surrounding hazards. This IK also plays a vital role in giving the communities a deep understanding of their environment, especially areas that are very prone to natural hazards. For the local communities to identify and differentiate, fluvial flooding and pluvial flooding indicated that the local people have a wide understanding of the context of their environment. From the results, it is clear that the IK is embedded within the cultural practices of the local communities as most of them will be related to the history for such understanding (Mercer *et al*., 2010).

Flood awareness is vital because it serves as a guide in most local communities during different flood events. For instance, the ability of the local people to be aware of the "normal annual flooding" as an advantage for agriculture due to the water it brings to the swamps contracts sharply with how devastating extreme annual flooding" is. This awareness enables local communities to develop adaptative strategies like timing their planting activities to meet the regular annual flooding. At the same time, they also prepare for the potential devasting extreme annual flooding (Nyong *et al*., 2007). These findings add to the fact that IK should be formally included in disaster risk management strategies as it is not only essential but helps in effective preparedness, mitigation, and response to disaster in The Gambia.

5.1.2 Use of Local Indicators for Predicting Flood Severity

Local indicators identified in this study, for example, watermarks on bricks or trees to determine the seriousness of flood, explained the practicality and the local nature of the IK. These indicators are easily interpretable and readily available for all community members, thus making the indicators a very effective mechanism of local monitoring and local early warning strategy. The ability of the local people to observe natural features to determine environmental changes indicates the indigenous knowledge system in The Gambia (Rochmi, 2015). Local indicators are fundamental in The Gambia as formal meteorological and hydrological monitoring stations and information are limited and must reach the local people as expected. In situations like this, IK bridges the gap of an uninformed society where IK complements scientific knowledge (SK). Moreover, the use of local reference points, as seen in these findings, can inform the development of community-based early warning systems that are culturally appropriate and widely accepted by community members (Gaillard & Mercer, 2013).

5.1.3 Anticipation Based on Rainfall Pattern

The local people's ability to anticipate flooding based on the duration and intensity of rainfall demonstrated the role of IK in disaster preparedness. The local people take proactive measures to mitigate the impact of floods based on their ability to understand the ecological system of their society, which is an important contribution to the results of this study. When there is prolonged rainfall and the intensity is high, the local people can prepare for flood by temporarily relocating to a safer place or reinforcing their houses before the flood starts (King *et al*., 2014; Roncoli *et al*., 2002).

These anticipations significantly enhance the local people's resilience and lower their vulnerability to flood hazards in the study areas. Research has shown that local communities with a very strong IK are most likely to withstand and recover from disaster shocks (Johansson, 2023). Incorporating this IK into DRM strategies in The Gambia, policymakers can make a more context-specific intervention in the local communities.

5.1.4 Vulnerability and Spatial Awareness

The finding of this study is in the area of communities' awareness of flood vulnerability, especially the increasing risk that households in low-lying areas face, which is very important for flood risk management in The Gambia. The awareness always allowed local people to identify safe areas and evacuation ways, a sign of practical and essential emergency response from the local communities. As mentioned by the respondents about the evacuation routes, this is how IK can directly contribute to disaster preparedness measures (Ütük & Baraçlı, 2024).

However, while such IK is significant, it has some limitations. As climate change is leading to more extreme and unpredictable events, relying on historical experience may be sometimes deceiving. To be able to address this, the current climate change and disaster risk management field is highlighting the need to integrate IK with scientific knowledge to enhance the local communities' resilience (Berkes, 2009). Bringing together the local communities, scientific society, and policymakers will result in an intense collaboration that can bridge the gap between IK and SK, leading to a more inclusive flood risk management system in The Gambia.

5.1.5 The Effect of IK on Flood Risk Management

The insight from this research significantly affects flood risk management in The Gambia and other similar contexts in the subregion. This research highlights the importance of recognizing and integrating IK with SK into formal disaster management frameworks in The Gambia. The indigenous knowledge system also provides a valuable wealth of context-specific, costless, applicable, and culturally relevant knowledge. If IK is integrated with SK, policymakers and disaster management agencies can develop a very comprehensive and inclusive flood risk management strategy that can address the specific needs of the local people (Mercer *et al*., 2010).

Moreover, this study's objective highlights the need to empower local communities through capacity building, where their local knowledge can be documented and shared on different platforms. When collaboration between the local communities and scientific institutions is well cemented, it will be easy to create a more inclusive disaster risk management that will give value and strengthen the IK and SK systems (Aitsi-Selmi *et al*., 2015).

5.1.6 Understanding the Causes of Flooding

The critical way to shape the local communities' responses to flood hazards is by highlighting the understanding of local people on the causes of flooding, which this object has tried to fulfil. Participants in this study were able to identify the cause factor of flooding. Both natural and human-induced factors contributed to the flooding in their local communities. Heavy downpouring was recognized as a fast trigger for flash floods in all communities. Deforestation, land degradation, inadequate food drainage systems, and peoples' attitudes were also identified as key factors that cause flooding. This result is in line with a similar research carried out by Salman and Li (2018) that emphasized the complexity of natural and anthropogenic factors in flood risk management.

The effectiveness of land use practices in The Gambia is challenged as the finding of this research recognized deforestation and soil erosion as key contributing factors to flooding. Despite deforestation being an economic-driven activity in The Gambia, this is leading to the reduction of vegetation cover that could have mitigated soil erosion and reduced the runoff into the river Gambia. Many developing countries in the subregion are currently facing economic hardship, forcing people to venture into activities that compromise the ecosystem (Nyong *et al*., 2007). It is vital for playmakers to have an understanding of this critical linkage when designing intervention policies that will not only address the flood risk in The Gambia but also advocate for a sustainable land use practice.

5.1.7 Influence of Socioeconomic Factors

The result of this research has shown that socioeconomic factors like population growth and poverty are contributing factors to flood risk. The building of houses in flood-prone areas is mainly driven by population growth, thus exposing communities to flood hazards. Poverty is also a key socioeconomic influencer; it has made many people build houses that are not solid enough to withstand flooding, making those people living there more vulnerable to flooding. In a similar setting, research carried out by O'Brien *et al*. (2006) stated that socioeconomic challenges limit the local communities' ability to construct a more resilient infrastructure and houses. As environmental degradation, especially deforestation, was mentioned as a cause of flooding, tree cutting is seen as a socioeconomic activity that is leading many lands to be prone to flooding. This lessens the ability of the land to absorb water, thus increasing the surface runoff (Bradshaw *et al*., 2007). As the local people understand the socioeconomic factor, it is important for policymakers to understand that to mitigate flooding, one must address the underlying socioeconomic drivers mentioned.

5.1.8 Indigenous knowledge (IK) in Flood Management

One of the main contributions of the objective of this research was the identification of IK used in the three stages of disasters: pre-flooding, during flooding, and post-flooding. The local early indicators mentioned by the local people demonstrated a key role of IK in the early warning system of the local communities toward disaster preparedness. All these indicators were developed from the local peoples' daily interaction with their environment, including observing the behaviour of animals, changes in riverine dynamics, observing celestial bodies, and observing trees. These were serving as an indication of the impending flood events in their communities.

The study further reveals how these local communities take early actions to mitigate the flood impacts. Among some of the early actions mentioned were adjusting housing structures, storing extra foodstuff, and relocating livestock to a temporary higher site. These were all pragmatic actions the local people used to mitigate flood effects. Even though these actions can be seen as simple, they have been very effective in reducing vulnerability and flood-related losses. The local people's ability to use their knowledge to mitigate the impact of floods increases local resilience and reduces the level of dependency on external aid, which may not be as timely as expected (Roncoli *et al*., 2002). Based on this, the studies identified three stages of flood disaster and the IK used in each of the stages. Below are the three stages:

Mechanism of Pre-Flood Risk Reduction

As flood risk reduction is a proactive phase in DRR, local communities in this study had implemented strategies that is to minimize any potential impact of flood in their communities. This result has shown that local communities in The Gambia are using both natural and structural measures to strengthen their flood disaster resilience.

The result reveals that the local communities have their own knowledge of ecological management, such as planting mangroves and other vegetation around the river bank. This, as they believed, could fortify the riverbank from erosion and river encroachment into their farmlands. Mangroves are known for their ability to reduce wave strength and trap sediments, which helps to reduce land loss and make a stable shoreline. This local practice has shown a deep understanding of the local people and their ecosystem and how they can preserve and protect it against natural hazards like floods. Research from other regions has shown that mangroves are very effective in reducing flood risk (Das & Vincent, 2009). It is fascinating to know that local communities in The Gambia that adopted the nature-based solution to flood risk are in line with the global best practice of flood risk management.

According to research, effective spatial planning is capable of drastically reducing flood risk (Douglas *et al*., 2008); thus, the local idea of maintaining a specific distance from the riverbank when constructing a house shows that the local people are aware of the floor's dynamics. Among the local people, maintaining a distance of at least 100 meters from the riverbank is a common practice in most of the local communities along the river Gambia. However, having a better understanding of spatial planning is needed in the communities, as river encroachment during high tides is becoming a nightmare in The Gambia. It is very important for policymakers to incorporate spatial planning during flood mapping to enable a practical approach to flood risk management.

Adapting properties, including building stronger foundations, using slope roofs, and sandbagging, reflects the community's proactive approach toward disaster preparedness. These measures are affordable and practical, utilizing local materials and knowledge to prepare for anticipated disasters. The use of IK in property adaptation is in line with findings from other studies that emphasize the importance of local knowledge in building flood-resilient structures (Walshe & Nunn, 2012; Das & Vincent, 2009). Moreover, these practices are easily replicable and accessible, making them ideal for widespread adoption in similar flood-prone regions.

IK During Flooding

IK is crucial "during flooding" as it is a guiding knowledge in communities' actions and responses to flooding. The local people's ability to adapt and respond to disasters mentioned includes real-time monitoring, evacuation decisions, and means of evacuation.

The use of natural indicators like trees to gauge the flood water level helps to inform the local people of immediate and reliable flood warnings, which can help them make a swift response. This IK is similar to the early warning systems in some local communities in the Pacific Islands, where natural indicators such as changes in animal behaviour or clouds are used as a means to predict floods and cyclones (McAdoo *et al.*, 2009). This monitoring method employed by the local people can, on many occasions, pass timely information where early evacuation and other proactive actions can be taken.

The result of this study shows that the decision to evacuate during flooding is solely the responsibility of the household head, depending on the severity of the flood at that time. The decentralized method of making the decision to evacuate during flood shows the autonomy of family heads to make decisions based on their experience and IK. However, there is a gap in this preparedness as local community members have no specific evacuation centre during a flood or disaster. Paul (2012) suggested that the pre-identification of evacuation centres and routes is a very efficient and vital system during evacuation.

Adaptation is a very common mechanism within the local people in The Gambia as they are known for using locally available resources like carts or walking during evacuation. However, these local means of mobility, even though sometimes overwhelmed by flooding, have proven to be very cost-effective means of transportation during flood disasters in local communities in The Gambia. Where there is no motorized means of transportation available, similar transportation systems, such as the case of The Gambia during evacuation, are mentioned in similar developing countries (Thompson *et al.*, 2017). As seen in this means of evacuation, the local communities have demonstrated the resilience and practicability of the IK in flood disasters in The Gambia and beyond. Meanwhile, if this means of evacuation is enhanced by modern means of transportation, it will be more effective and efficient.

IK During Post-Flooding Recovery

Post-flood recovery entails returning to normality and rebuilding livelihoods back better as enshrined in the Sendai Framework for DRR. IK in Gambia serves as a guiding principle of recovery efforts of the local communities as it helps in cementing sustainability and community cohesion.

Even though rebuilding on the same spot puts the new house on elevated ground, as mentioned by the respondents, the tendency to do this is mainly influenced by cultural attachment, land availability, and economic limitations. While this practice by the local people showcases resilience, it may not be the best method of recovery from flood disasters. Building a house in the same flood-prone spot will only espouse poverty and vulnerability, leading to a cycle of destruction and reconstruction (Tanvir Rahman *et al*., 2015). This calls for a need for local people to be involved in risk-informed urban planning that factors future flood risks and advocates safe house-building practices.

Agriculture, being the main livelihood in The Gambia, is a focus of the post-flood recovery effort. The local people demonstrated adaptability by making use of the residual moisture for planting crops. This IK is significant for food security and economic recovery in the flood-affected communities in The Gambia. It is proven that traditional agricultural practices, such as planting flood-resistant crops, can significantly increase local community resilience to disaster (Morton, 2007). However, respondents highlighted the need for support as regaining one's lost livestock and having no access to disaster relief always hinder their recovery process.

5.1.9 Role of IK in Modern Disaster Risk Management

While it is difficult to achieve a holistic approach in modern disaster risk management, there is a serious need for the integration of IK into modern disaster risk management. IK, being a cultural and experience-based knowledge, when integrated with SK, will be able to address the challenge of risk management holistically in the subregions. For instance, community-based early warning systems that incorporate both local indicators and meteorological data could provide more accurate and timely warnings for the local communities, thereby enhancing community preparedness and response to disaster (Dube *et al*., 2015).

Moreover, the study also emphasizes the need for IK sharing and transmission of IK from generation to generation. This will enable the young generation to be fully aware of the IK thus making it very sustainable and active. Formal education that encourages the value of IK could play a very important role in preserving the social and cultural fabric of society and preserving the local knowledge system (Berkes, 2009).

5.1.10 Importance of Indigenous knowledge (IK) in The Gambia

IK, being well known for its practical disaster management, also has wider benefits to preserving culture, economic sustainability, and education. This has been proven over the years, and in this study, IK can preserve cultural heritage and education.

The ability of IK in The Gambia to strengthen disaster preparedness is always evident in that local communities depend on natural indicators for early warning. Disaster preparedness paves the way for timely intervention thus reducing the impacts. As stated by Basher *et al*. (2006) early warning systems help in reducing disaster-related damages.

Community cultural heritage cannot be fully preserved with active IK preservation. This, in most cases, helps society or individuals to have a cultural identity. When there is cultural ownership, IK is respected, preserved, and handed down to the next generation. Due to cultural ownership, community members endeavour to abide by the IK as a valuable flood risk management practice. Hiwasaki et al. (2014) stated that the cultural value of IK makes it very important to integrate it into formal disaster management frameworks in disaster-prone regions.

IK is an intergenerational transfer of knowledge and a strong medium of traditional and cultural education in The Gambia. It preserves the country's traditional and cultural heritage and serves as a means of managing flood risk. Teaching IK to the next generation gives the students a sense of ownership, responsibility, and preparedness, thus contributing to the local communities' resilience in The Gambia.

The sustainability and widespread adoption of IK indicate its cost-effectiveness (J. Mercer *et al*., 2007). Where expensive modern technology is not available or applicable, IK's accessibility is very important in disaster risk management. As indicated in the study, IK fully relies on locally available resources and knowledge to provide a cost-free approach to flood risk management.

The local people's knowledge of flood patterns, impacts, and occurrence depends on the historical knowledge enshrined in IK in their society. This historical knowledge in The Gambia helps local communities to know flood-prone areas and the season of flooding so that they can develop an appropriate mitigation strategy (Devkota *et al*., 2014).

5.2.0 SECTION 2: The flood risk of the communities in The Gambia

5.2.1 Flood Risk in The Gambia

Multiple factors, such as rainfall, slope, land use/land cover (LULC), distance from the river, soil type, and elevation, generated a flood risk map for The Gambia. All these factors were crucial and helpful in developing a comprehensive flood risk analysis for The Gambia.

During the analysis of this work, the flood risk in The Gambia was categorized into five levels: very low, low, moderate, high, and very high. The classification showed that the most significant proportion of The Gambia fell into the "moderate flood risk" category, covering 37.71% of the area. This was followed by "low flood risk" (35.88%), "high flood risk" (18.51%), "very low flood risk" (5.27%), and "very high flood risk" (2.63%).

A research carried out in Nigeria by Ologunorisa & Abawua (2005) conducted a similar study, identifying high-risk flood zones based on factors like rainfall, elevation, and proximity to rivers. They were able to discover that the low-lying areas with high population densities were the most vulnerable, reflecting the current finding of this research in The Gambia, where the areas at high risk are with dense populations. A similar work in Ethiopia by Gebre (2015) analysed flood risk in the Awash River Basin, where the area was related to high rainfall and low elevation, thus making the area the highest flood risk. This is consistent with our study, where regions like WCR, KM, and Banjul, which have high rainfall and low elevation in The Gambia, showed higher flood risks than other areas like URR, which have lower rainfall and higher elevation. Islam & Sado (2000) had assessed flood risk using parameters similar to those in this study. Their findings showed that areas with high rainfall and low elevation were more susceptible to flooding, highlighting a universal trend across different geographical regions in Bangladesh.

As shown in the flood risk map, elevation played a critical role in determining flood risk areas in The Gambia. Areas with higher elevations were less prone to flooding, whereas areas with lower elevations were more susceptible. The western part of The Gambia (WCR, KM, and Bjl), characterized by lower elevation, is more prone to flooding compared to the eastern part (CRR and URR). Like the result of this research, Mogaka (2006) identified that low-lying regions near river basins in Kenya were highly vulnerable to flooding, similar to the findings in The Gambia. Based on the result of this research, it is clear that regions with lower elevation experience higher flood risk, similar to research done by Wang & Gu (2016) in China.

Flood risk is significantly influenced by the slope of the land as areas with steep slopes experience quick water flow, reducing infiltration and increasing surface runoff and erosion. The result of this study area shows that the slope ranged from 0° to ≥10°, with higher slopes near rivers indicating higher flood risk. A similar study in the Umgeni River Basin by Smithers & Schulze (2002) and in Nepal's mountainous regions by Shrestha *et al*. (2020) pointed out that regions with steep slopes used to have higher flash flood risks as a result of rapid runoff. This is what the communities in steep slope areas in The Gambia are facing.

In this section, LULC types in the study area predominantly included croplands, rangelands, built areas, and some trees. Built-up areas and farmlands were more susceptible to flooding due to reduced infiltration and increased runoff in the seemingly densely populated areas. As in this result, research has shown that areas with very low LULC and are found to be urban areas are found to be at high risk of flood. This result is similar to what Kizza *et al*. (2009) had done in Uganda, pointing out that Kampala has a high flood risk as a dense and low LULC area. Farmlands that are close to the River Gambia are more vulnerable to flood in The Gambia, as indicated in the result. This is in confirmation to research carried out in India by Sharma *et al*. (2019), stating that agricultural lands in the Tapi River Basin were more vulnerable to flooding due to reduced infiltration.

Water infiltration and retention are most of the time influenced by soil type. Based on the result, the primary soil types in The Gambia are fluvisols, luvisols, nitosols, and regosols. Fluvisols near river basins show different flood risks. This current research done by Daba & You (2020) concluded that fluvisols in the Blue Nile Basin's flood risk is higher than others due to poor infiltration. Areas with clayey soils have higher flood risks because of their low infiltration rate. Ahmad *et al*. (2011) in their research noticed that in Pakistan, clay soil experienced low infiltration, which is confirmation of the soil type identified in The Gambia in this research.

As rainfall is a key driver of flood risk assessment, this research identified the need to mitigate the effect of rainfall in regions more prone to flood effects. As shown in the result, regions like the West Coast Region (WCR) and Kanifing Municipal (KM) were more susceptible to flooding as they had more rainfall than the other regions in The Gambia. Nguyen *et al*. (2021); Ugonna *et al*. (2016) and Komolafe *et al*. (2015) and in their studies stated the influence of rainfall on flood as they view it as a main driving factor of flood in their areas of study. This is in consonant with the current research, which highlighted the role of rainfall in triggering floods in The Gambia, as floods in the study area are seasonal floods.

Proximity to the river can greatly influence flood risk, as indicated by the results of this research. Areas closer to the river were more prone to flooding due to higher water levels during heavy rainfall and elevation in the study area. In Tanzania, a study by Tarchiani *et al*. (2020) shows communities near the river experience a high risk of flood that communities far from the river while Ullah *et al*. (2020) also noticed a similar experience in their research.

Disaster planning in The Gambia should be a national concern where community-based disaster risk management is well utilized. In areas classified as high and highly high-risk, the primary focus should be on establishing resilient emergency services and implementing comprehensive evacuation procedures. This approach leverages local knowledge and participation in disaster planning and response, fostering a sense of community ownership and responsibility for disaster preparedness, responses, and recovery (Sin & Shin, 2017). An effective disaster planning strategy should be adaptable and flexible to effectively address evolving flood hazards and changing climatic patterns in The Gambia.

5.2.2 Buffer Mapping in The Gambia: A Regional Perspective

In Figures 17 to 24, the buffer meters are used to make an estimation of the area within which the flooded waters from the river and water bodies could potentially spread across the land. This has shown a knowledge gap among the local people saying in other to build a house, one needs to go at least 100 meters away from the normal floodplain. Looking at this result, is it obvious that the distance to which one can build a house away from the normal floodplains varies from region to region. Indicating that the 100 meters mentioned by nearly all the FGD in each region is not sufficient knowledge to base your decision on spatial planning. However, there is still a level of experience as some regions such as CRR South (92 m) and URR (72.5 m) could not reach the approximated 100 meters by the local people. This has demonstrated that local knowledge when validated is not 100% correct or wrong.

Banjul is located on a very low-lying island, making the city very vulnerable to flooding, especially during the heavy rainy season. Sea level rise and heavy rainfall as projected by Bojang *et al*. (2023) in a climate change model indicated that Banjul is vulnerable to flooding in the near future. Given this level of vulnerability, the buffer zone highlights areas that are highly at flood risk. Kanifing being located adjacent to the Atlantic Ocean, is also susceptible to coastal flooding, especially given its flat land. The town's proximity to the river and ocean makes it more vulnerable to both tidal and riverine flooding depending on the level of precipitation in the area (Sarr *et al*., 2024). Urbanization within the WCR is a potential problem as the proximity of settlements to the river is on the increase thus making the local communities along the river vulnerable to flooding. The buffer zone of 172 meters in the region shows areas that are increasingly susceptible to flooding. This also makes the WCR face further future high flood risk especially communities that are building their houses within the red buffer zone. A buffer zone of 172.5 meters around river and tributaries in the LRR, shows the floodplain areas in the region. The LRR being dominated by the river Gambia, demonstrated a riverine flooding in the region. The mapped buffer areas along the water bodies and the river in the region show a high level of flood risk that can be triggered by rainfall-induced riverine flooding. With the continuous climate change, NBR is expected to face increased flood risk due to heavier rainfall events. A buffer area of 166 meters, shows the distance to which the effect of flood can damage the assets of the vulnerable communities. Both CRR South and North of the 92-meter buffer and 164.5 meter respectively show some degree of susceptibility to flooding. CRR North having a higher level of flood risk than the South based on the data processed has highlighted the need for proper monitoring of the development process in the region to avoid further damages from flood.

5.3.0 SECTION 3: The flood impacts on the communities along the Gambia River

5.3.1 Flood impacts on local communities in The Gambia

The survey has shown a very significant gender imbalance within the heads of households, showing 69.7% of males and 30.3% of females. This reveals a trend in a patriarchal society, most especially in rural communities where men take dominion in decision-making. Smiley *et al*. (2020) reveal a similar finding where men are predominantly the head of households in rural communities in West Africa. Women, who are mainly caregivers, lack access to decision-making, thus making the local communities less resilient to floods, which is crucial during disasters (Alam & Rahman, 2014). A low education level (43.8%) among the respondents is a great concern as it correlates with disaster preparedness and adaptive capacity (Jha & Gupta, 2021). As seen in Daniel Idoko, (2016)'s work, communities that depend on farming are more vulnerable to flooding as the majority of the respondents are farmers in the study area. Over 51% of the respondents lived in their communities for over 20 years. Staying in a place for a long time helped in the development of IK, but it also shows a sign of reluctance to relocate even though they are prone to disaster risk; this trend was also observed by Huang et al. (2024) in an attempt to study flood-prone communities in Southeast Asia. As observed in the result, a large household number (59% with 6 or more household members) affects post-disaster recovery as more dependents can strain resources (Safapour *et al*., 2021).

5.3.2 Flood Experience and Preparedness

These results reveal a very high flood experience where 98.6% of households reported that a flood had happened in their communities, while 70.6% said that water had entered their houses. This indicates a high level of exposure to flood risk. Rahman *et al*. (2018) revealed in a similar study that affected households regularly experience inundation. However, with all this exposure in the study area, preparedness still needs to be improved: 2.1% had flood warnings, and 88.4% did not know any evacuation centers in their communities. This lack of preparedness is similar to the findings of Perera *et al*. (2019) where flood-prone communities in Sri Lanka were reported to be insufficiently informed about DRR strategies. The lack of an early warning system (EWS) contributes significantly to flood-related disasters. This has made EWS very crucial in disaster mitigation, as stated by Samansiri *et al*. (2023) in a similar study in Pakistan. In contrast, local communities in countries like Japan with very effective EWS show a higher level of preparedness and a decrease in flood mortality (Dasgupta *et al*., 2020).

The absence of an evacuation centre, as reported in this study, further increases the vulnerability of the local communities. Sutton *et al*. (2020) Indonesia shows in their study the importance of having a clear, designated, safe place for effective disaster response. The need for more evacuation infrastructure in the communities along the River Gambia points out a critical gap in disaster management planning.

5.3.3 Impacts of Floods on Households and Local Communities

In this study, floods were unanimously acknowledged to have devastating impacts, most especially on farmlands and roads. During the FGD, participants noted that farmland (32%) and roads (31%) were the most commonly and severely affected assets in their communities. This finding is consistent with that of Hu *et al*. (2018), who stated that agricultural lands were more vulnerable to flood in rural communities.

Many participants mentioned that their houses are less affected than their farmlands, and most claimed that their buildings are on highlands even though the July 2022 flood overwhelmed them (Aderogba, 2012). Elevation is also a key factor in flood risk management and resilience. However, most participants stressed the need for support as they believed that their local strategies were insufficient to mitigate flood impacts. Banerjee (2010) found that local coping strategies, while helpful, often require external support to be fully effective.

The Pearson Chi-square analysis reveals that many socio-demographic factors were significantly associated with flood impacts in the study area. For example, region and gender were strongly linked to flood-related death. This can be attributed to different regional flood management and social norms that affect gender roles during disaster management. This regional disparity is in line with the study carried out by Rakib *et al*. (2017), where regions that are marginalized suffer more severe flood impacts as a result of weaker disaster preparedness infrastructure.

The significant association between flood impacts and factors like occupation, type of settlement, and size of household (as seen in the impact of water entering houses) shows that socioeconomic factors play a key role in household vulnerability. This is supported by Cutter (2017) and Birkmann *et al*. (2015), showing how lower-income and larger households often have limited resources for disaster mitigation or recovery from flood disasters. As observed by Few *et al*. (2021), the association between years lived in the community and flood impacts indicated that even long-term residents, with their indigenous knowledge, may not protect themselves effectively from the effect of floods.

5.3.4 Preparedness for Flood Risk

Preparedness was significantly associated with many socio-demographic factors like age, education level, and household size. The results reveal that older household heads, people with higher education levels, and smaller household sizes were more likely to have access to resources. This aligns with the study by Elum and Lawal (2022), which suggested that people with higher education levels were better equipped for flood risk due to greater access to resources and information.

The lack of flood risk in the local communities surveyed, as reported by the majority of the respondents, indicated that there is a massive gap in DRR efforts in The Gambia. In flood mitigation and preparedness, flood risk maps are crucial. Research by Erena *et al*. (2018) in Ethiopia has suggested that communities that have access to flood risk maps are better prepared for floods as most of their tools include local adaptation strategies. The absence of flood risk maps in local communities along the river Gambia may be a contributing limitation to flood preparedness, showing the need to improve flood risk communication in The Gambia.

In a similar vein, the Chi-square tests show that region, education level, and occupation were significant factors in determining whether households knew of any evacuation centres or made anticipatory flood preparations. This shows that more economically stable and highly educated households are better equipped for proactive response to flood risks. Koks *et al*. (2015) found out in their studies that households with high education and higher income are more likely to take part in flood risk reduction practices.

5.3.5 Local Communities' Knowledge of Flood Coping Strategies and Management

The binary logistic regression analysis shown in Table 18 reveals the socio-demographic factors that are influencing local communities' knowledge of flood coping strategies. Region, gender, age, ethnic group, education level, household size, settlement type, and the number of years one lived in the community were all significant factors. This result highlights the complex nexus between socio-demographic features and the ability of local communities to cope with floods.

The findings highlight a significant regional difference in flood coping strategies. Communities in KM (CL 9.250-3.739 and p= .000), NBR (CL-1.038-4.824 and p= .002), and CRR (CL3.535-0.141 and p= .034) were discovered to have a more substantial positive knowledge on flood coping strategies when compared to URR. This variation in regions is related to different exposure to floods, their local adaptation measures, and stakeholders' support. This finding is in consonant with Nkwunonwo *et al*. (2020), who found that regions with high levels of flood exposure are likely to develop a strong IK of coping strategies.

Gender also plays a crucial role in flood coping strategies in the local communities, with men-headed households (CL -0.303-3.014 and p= .016) being more likely to have more positive knowledge than women-headed households. This result highlighted a gender disparity in flood resilience where women-headed households may need support to improve their capacity to cope with floods.

Household heads that are in the age bracket 20-29 (CL 11.669-1.553, p = .010) were significantly associated with positive knowledge of flood coping strategies. This could be because of their age being open to learning modern coping and adopting strategies. The Mandinka ethnic group (CL 3.557-0.782, p = .002) shows a significant association with the positive knowledge of flood coping strategies, which is attributed to communal solid support and shared IK within the group. In contrast, ethnic groups like Fula and Wolof showed no significant association, suggesting a cultural difference can affect flood preparedness and responses.

Education significantly influences flood coping strategies, as households with informal education (CL -0.945-4.270, p = .002) were likely to depend on local coping strategies. As also stated by Magni (2017), less formally educated local communities depend on indigenous knowledge. Rural households (CL 0.042-4.377, p = .055) have a near-significant association with local coping strategies, suggesting communities in the rural settlement, even though they face limited formal support systems, often develop their indigenous knowledge to cope with floods.

The size of the household was another strong predictor of knowledge of coping strategies. Households that have 5 or fewer members (CL 4.224-0.416, p = .017), 6-10 members (CL 4.545-1.519, p = .000), and 11-20 members (CL 6.120-2.764, p = .000) all show a higher likelihood of local coping knowledge of flood. This result suggests that larger household members may have more labour and resources to cope with floods (Mfitumukiza *et al*., 2020). Years lived in the community also played a role, with households residing for 6-10 years (CL 7.909-0.089, $p = .045$) and 16-20 years (CL 2.283-0.123, $p = .029$) showing significantly higher knowledge of local coping strategies. Ndue *et al*. (2023) similarly found that long-term residents in flood-prone areas tend to accumulate more experience that will inform their flood response activities.

5.3.6 Local Flood Coping Strategies and Knowledge of Flood Management

The flood local coping strategies identified in Table 15 like using sandbags, constructing contour bands and dikes, and raising houses elevation, were all commonly employed by the local communities in The Gambia. These coping strategies are in line with Yin *et al*. (2021) and Jonga *et al*. (2021) who stated the use of sandbags and raised house elevations is a common mitigation to flood in flood-prone regions.

However, the focus on controlling the impact of floodwater from damaging assets instead of controlling the sources of floodwater may limit the long-term effectiveness of these strategies. As Iacob *et al*. (2014) observed, a comprehensive flood management approach should also include upstream water management and drainage improvements to reduce overall flood risks in communities.

The FGD highlighted a substantial understanding by the local communities of the causes and impact of floods. FGD participants highlighted riverine and flash floods, which happened primarily due to the rainy season (June to October). They also acknowledged that flood is exacerbated by inadequate preparation and socioeconomic limitations. Participants from LRR demonstrated local awareness of spatial vulnerability as they were able to identify a high land in the village square as a temporary evacuation centre. Xu *et al*. (2024) also mention the same in their studies, which state that communities that are prone to flood often develop strategies to mitigate risk through spatial and environmental observation.

5.4.0 SECTION 4: The perception of local people on the effect of climate chang

5.4.1 Climate Change Perception

As a result, flooding is a prevalent issue in The Gambia, while other extreme weather events are less common. The result indicated significant agricultural vulnerability to climate shocks, with 90.05% of respondents reporting agricultural losses (Figure 39). This finding is in line with existing literature that highlights the severe impact of climate change on the agriculture sector, especially in regions dependent on rain-fed farming like The Gambia. According to Arata *et al*. (2020); Kindie *et al*. (2015), climate variability and extreme weather events like floods and droughts are major drivers of agricultural losses, affecting crop yields and leading to food insecurity in many developing countries.

The relatively low percentage of livestock losses (9.72%, figure 40) from the respondents suggests that while livestock is important, it may not be as directly impacted by the same climate shocks affecting crops, or could be that mitigation strategies employed by the local people as mentioned during the FGD (e.g., movement of herds to highlands, supplementary feeding by not allowing the animals to go out during heavy downpouring) are more effective. However, despite the small percentage of livestock loss, it can have a great impact on households that rely heavily on animal husbandry for income, food, and cultural practices (Thornton *et al*., 2009).

The climate change perception index (table 16 and figure 41) reveals a moderate average perception score of 40.6 out of 100. However, the wide range of scores (from 0 to 100) and the distribution across perception categories suggest significant diversity in awareness and understanding of climate change within the study area population. This variation in climate change perception can be attributed to multiple factors, including education, access to information, and the socioeconomic status of the respondents.

I. Low Perception Levels:

A notable 64.65% of respondents have either a very low or low perception of climate change. This finding is consistent with studies indicating that in many developing countries, particularly in rural areas, awareness of climate change is often low (Maponya *et al*., 2013). This can be due to limited access to information, high illiteracy levels, and a need for more engagement with global discourses on climate change (Niles *et al*., 2015). Low perception levels can affect the adoption of adaptive practices, which are crucial for mitigating the impacts of climate variability on agriculture and livelihoods in local communities.

II. High Perception Levels:

On the flip side, 35.35% of the population has a high or very high perception of climate change. This group is likely more informed and may have better access to resources such as education, media, or community programs focused on climate change. Higher perception levels are often linked to greater adoption of adaptive strategies, such as crop diversification, water management, and the use of improved seed varieties; hence, the majority of the study population are farmers (Mertz *et al*., 2009). This group is also likely to support and participate in policy initiatives aimed at addressing climate change in The Gambia.

The high percentage of agricultural losses combined with moderate climate change perception raises concerns about the local communities in The Gambia's vulnerability to future climate shocks. As the majority of the Gambians are farmers, agricultural losses can lead to decreased household incomes, food insecurity, and increased poverty levels (Deressa *et al*., 2009). Suppose climate change perception remains low, especially in the most affected areas. In that case, there is a risk that communities may not take sufficient steps to adapt, leaving them even more vulnerable to climate change in the future. The result suggests that efforts to increase climate change awareness are essential, mainly targeting the 64.65% of the population with low or very low perception. This could involve educational programs, community workshops, and the use of local media to disseminate information on climate change and its impacts. Increasing awareness is a key step towards building resilience, as it empowers communities to adopt mitigation practices and supports the implementation of climate-smart policies in their local settlements (Unnikrishnan & Nagendra, 2021; Adger *et al*., 2003).

Moreover, targeted interventions to support agricultural practices, such as introducing climate-resilient crops, improving water management systems, and providing access to timely weather information, could mitigate the impact of climate shocks in local communities. Such strategies are essential to reduce the vulnerability of agricultural households and enhance their capacity to cope with future climate-related challenges in The Gambia and the sub-region.

The results on settlement type and perception show a clear contrast in climate change perception. Rural settlers have a very low (50%) perception compared to urban settlements (19.3%). This difference may reflect the difference in level of education, information access, and exposure to events on climate change in their communities. Research shows that rural communities tend to have a low awareness of climate change because of limited levels of education and information (Ali & Rose, 2021; Niles *et al*., 2015). Urban areas have better access to social amenities and information that continuously enhance climate change awareness (Adger *et al*., 2003).

The result of this section shows that gender is a key player in climate change perception. Women have a 26.4% very high perception of climate change compared to men at 10.6%. Research carried out by Dankelman and Naidu, (2020) shows that women, especially those in the agricultural sector, have more awareness of climate change than men. The women's high perception in the study area may also be linked to the role they played in household management where the impact of climate variability on food security and water is seriously felt (Sultana, 2022).

Age also has a significant influence on climate change perception, especially with older populations (age 60 and above) 39. 6 % with a very low perception level, indicating a generally low climate awareness. Unlike the younger or working population, who are most likely to have access to climate change information, education, and media, they tend to have a higher climate change perception, with 31.4% of those aged 40 – 59. The general perception of climate change in relation to age is low, as 28.8% reported it to be very low, and 15.3% reported it to be a very high perception score. As mentioned by Lowe *et al*. (2022) and Paterson (2020), younger or working class are more likely to be aware of global issues like climate change than older groups as they have more access to technology and education.

The result features a significant contrast in climate change perception across ethnic groups and religious groups. For example, the Wolof ethnic group has a disproportionately higher perception rate compared to others, with a percentage of 52.9%. These distinctions reflect cultural factors, like traditional or local knowledge systems, community practices, and religious beliefs, that influence how climate change is received and responded to (Ewane & Lee, 2020).

Educational level, marital status, and occupation have also a significant influence on climate change perception. For example, individuals with higher education show a very high level of climate change perception, with 36.6% of those in Tertiary/University education. This illustrates that education helps an individual to have a better understanding of complex environmental issues like climate change and how the acquired information impacts their perception level (Ali & Rose, 2021). Occupation also has a high influence on individuals' perceptions, especially among highly skilled workers who have access to information and resources about climate change (Mertz *et al*., 2009).

5.4.2 Perception of the Impact of Climate Change on Agricultural and Livestock Losses

Tables 18 and 19 present the logistic regression results revealing the perception of the local people on the impact of climate change, specifically floods and droughts, on agriculture and livestock in the local communities in The Gambia. The finding shows that drought as a climate change effect has significantly increased the risk of agricultural losses, with an odds ratio of 181.55, meaning that the individuals experiencing drought are 181 times more likely to face agricultural losses than individuals who did not experience drought in their community. In a similar result, floods also increase the risk of agricultural losses by an actor of 8.362. meaning those who experience flooding are 8 times more likely to experience agricultural losses than those who did not experience flooding in their communities. This result is in consonant with global research, showing that most extreme weather events are seriously affecting agricultural growth, especially in regions that depend on rain for agricultural activities, flooding, and drought (Moyo, 2016; Deressa *et al*., 2009).

Interestingly, from these results, the effect of climate change on livestock losses is different from the effect of climate change on agriculture losses. The risk of livestock losses is not increased by drought and flooding as the odds ratios of 0.005 and 0.119, respectively. These contrary findings can be explained by the adaptive strategies that many households employ to protect their livestock during climate change and extreme weather events. For example, moving animals to a safer location, as mentioned in the FGD, selling the animals before the conditions get worse, or using supplementary feeds when the extreme event persists (Thornton *et al*., 2009). Based on this finding, while flooding and drought severely impact crops, livestock may be more resilient or benefit more from the local people's local risk mitigation practices.

GENERAL CONCLUSION

6.0 Introduction

The thesis sought to examine the role of IK in flood risk management and explore the impacts of flood and climate change perception of the local people in The Gambia. The analysis was based on a mixed method where each method was achieved under some specified research methods. This section of the thesis will emphasize the following: a summary of the thesis's main findings, a summary of the thesis's main contributions to knowledge and policy, the research's current limitations, and recommendations for further studies.

6.1 Summary of the thesis's main findings

In an attempt to achieve the aims of this thesis, the main finding reveals that there is a high level of flood disaster awareness in The Gambia local communities. This was due to the local people's use of IK to predict flood severity and observe rainfall patterns. IK was presented to be central in the three stages of disaster management: pre-flooding, during flooding, and post-flooding. This study also discovered some effective local indicators used in flood disaster prediction in the local communities in The Gambia, thus showing the importance of IK in disaster preparedness and response. Adding to this section, some socio-economic factors and environmental (poverty and deforestation) were discovered to be key drivers that influence flood risks in the local communities. A critical factor in making a more proactive flood risk management was strongly related to integrating IK with SK during this study.

This also identified a detailed flood risk by producing a flood risk for The Gambia. There was a classification of flood risk in The Gambia under the following categories: moderate (37.71%), low (35.88%), high (18.51%), very low (5.2%), and very high (2.63%). During the analysis, factors like rainfall, slope, land use and land cover (LULC), soil type, and elevation were used to classify flood risk. Elevation and slope were noticed to have impacts on flooding as those areas were identified to be more susceptible to flooding. Areas that were identified to be more vulnerable to flooding were mainly found to be in the urban (Western part of The Gambia). This thesis also highlighted that urban settlements and farmlands, especially areas with fluvisol soils, are more at risk of flooding. Other primary drivers of flood risk were rainfall and the proximity to rivers. For example, regions like the West Coast Region and Kanifing were seen as vulnerable because of their high rainfall and proximity to the river.

The buffer zone in the maps serves as a critical tool for urban and rural planners and disaster management authorities in identifying areas that are at high risk in various regions. Urbanization, especially around the coastal and riverine areas in Kanifing has increased the urban's flood vulnerability. As mentioned by Kavegue and Eguavoen (2016) unplanned and poor development and drainage systems can increase the flood risk in red-highlighted areas.

The buffers flood risk area maps for each region, also emphasize the urgency of a good and sustainable infrastructure that will accommodate natural water flow and mitigate the flood damage in the country. These findings will make a strategic land-use planning policy that could consider the buffer as a" NO-BUILD" area. Better still the government could implement flood defenses such as retention basins, levees, or green infrastructure in the country (Douglas *et al*., 2008).

The thesis has also provided a very comprehensive insight into the flood impacts on the local communities in The Gambia, focusing on the role of gender, coping strategies, and preparedness. This study shows a gender imbalance within household heads, where men are predominantly the majority. This is a reflection of an active patriarchal society. The flood vulnerability of the local communities could be identified due to their low education level (43.8%) and high dependence on subsistence agriculture. Despite the considerable number of flood households experiencing 98.6%, it was identified that the local people still appealed for help as their preparedness was insufficient. Notably, 88.4% were identified as unaware of any evacuation centre. This highlights a severe gap in the disaster management system in The Gambia, especially infrastructural preparedness. The impact of floods was discovered to be more severe on agricultural (farmlands) activities and infrastructure (roads). The flood impacts and recovery were identified to be influenced by socio-demographic factors like gender, region, and the size of the household. There was a strong association of preparedness for flood risk with age, level of education, and household size, suggesting that older, highly educated persons and with a smaller member of the household are more prepared for flood, vice vasa. There was a variation of coping strategies and level of effectiveness among regions.

Additionally, the thesis investigated the impact of climate change on agriculture and livestock, placing more focus on local people's perception of climate change. The study reveals floods as climate change-related disasters, making 90.05% of the respondents relate their agricultural losses to the phenomenon. The study also reveals the climate change perception index showing a moderate score of 40.6, with many of the population exhibiting very low (64.65%) or high (35.35) climate change awareness levels. The study demonstrated that climate-induced disaster, particularly flooding and drought, has a significant impact on agriculture. Drought was seen to increase the level of agricultural losses by a factor of 181.55 and flood by a factor of 8.362. Gender, age, settlement type, ethnic group, educational level, and occupation were all seen to be factors that influenced variations in climate change perceptions.

6.2 The contribution of the findings to knowledge

The research contributes to the insight into how IK can be a complement to modern disaster risk frameworks by highlighting "first-hand" practical knowledge of IK in flood preparedness and mitigation. The finding demonstrated that in the absence of formal meteorological data, the indigenous people have their means of providing timely and relevant information on the hazards around them. The study also adds to the literature on the different IKs used in three different stages of flood disasters, which can be a reference point during the integration of IK and SK in The Gambia and West Africa at large.

It further illustrated how IK can be used to enhance community resilience and preparedness. By integrating factors like slope, elevation, rainfall, LULC, soil type, and distance from the river in producing a flood risk map of The Gambia, this study enhanced the understanding of flood risk factors and regions in The Gambia. The use of geospatial data to produce a flood risk map and analyze IK in flood risk has contributed to disaster management and urban planning and a broader methodological approach to disaster risk reduction.

This research contributes to a better understanding of flood resilience and vulnerability in The Gambia by linking socio-demographic factors to flood impacts and preparedness. The study established that in The Gambia, gender imbalance, low education, and socio-economic factors are having a significant influence on disaster preparedness and recovery. The study filled a gap in understanding flood management in rural West African contexts by discovering local coping strategies and their effectiveness.

This study gives a better understanding of climate change impacts in The Gambia by detailing how varying perceptions affect local responses to climate-induced disasters such as floods and droughts. As this research concurs with the existing literature on agricultural vulnerability to climate-related disasters, it also provides a new insight into the differential impact on livestock. The study also shows that the moderate perception level and varying awareness demonstrated the need for a tailored climate change educational intervention. The research adds more insights into how different communities experience and adapt to climate variability by linking socio-demographic factors.

6.3 The Contribution of the findings to policy

This study's findings significantly impact policy development in The Gambia and similar regional contexts. Integrating IK into DRR policy will greatly help The Gambia, so policymakers are encouraged to give value to IK in the national DRR framework. To address flood management policies, this study highlighted socio-economic drivers such as inadequate infrastructure and poverty for policymakers to consider.

This study has a vital contribution to policy planning as the flood risk map and other related findings can be a guide for flood mitigation and response allocation in the country. As specified in the risk map of areas with very high and high risk, policymakers can use this information to prioritize and develop a deliberate flood risk reduction strategy. This finding also reveals the importance of community-based disaster risk management (CBDRM), which calls for policymakers in The Gambia and the subregions to consider the full participation of local people in policymaking.

As the findings have contributed to the disaster management and policy in The Gambia, the observed gap in the local communities' early warning system and preparedness for flood calls for policy interventions in The Gambia. In addition, the findings also suggested support for vulnerable groups like female-headed households low educated and overpopulated households by improving their capacity to cope with floods.

The severe impacts of climate change on agriculture call for the development and implementation of climate-smart agricultural adaptation strategies. On this, policymakers in this study are encouraged to intensify climate awareness campaigns most especially in rural communities where the awareness level was observed to be low.

The application of GIS, as seen here, is crucial in **flood risk management**. By visualizing the buffer zones and overlaying them with urban infrastructure, authorities can make informed decisions about where to focus flood mitigation efforts. This proactive approach, supported by GIS, can help reduce the impact of floods on the population of The Gambia and infrastructure. Furthermore, zoning policies from these findings can be developed to discourage development and construction in high-risk buffer areas.

6.4 The limitations of the research

Despite this research aims to bridge a scientific gap, it is very vital to make a reflection on a few limitations. The first limitation was the timing of the study's seasonal data collection hence floodings in The Gambia are seasonal (during rainy seasons). During these unprecedented times, most of the communities are not easily accessible because of the road infrastructure and mode of transportation.

Secondly, the timing for most of the data collection was a challenge because, during the rainy seasons, most of the local people in the rural communities are very busy putting more focus on their farming activities thus making their participation in the research a secondary activity if they agreed to participate, although some refused by say they are busy with their farming activities.

Thirdly, as explained in the methodology chapter, the research could not get into details of individual communities' flood risk maps due to the limitation of detailed quality data for such analysis in The Gambia. The researcher was only able to utilize the available data for risk analysis and hoped for further studies to be done in the future.

Furthermore, as contended in the literature review chapter, IK is often intertwined with ordinary daily practices, making it challenging to communicate its words verbally. Utilizing systemic instruments that depend on language as a chief device for information transmission implied that a portion of the LK aspects could have remained uncovered, as they must be uncovered through a drawn-out ethnographic stay and drenching in the day-to-day existence of the local people's way of life. Notwithstanding, the questions designed made an effort to ensure that as many dimensions as possible were discovered by focusing on the various stages of flood risk management —before, during, and after the flood.

Moreover, the selection of study areas was influenced by practicalities, proximity to the river, accessibility, and the safety of the researcher. Hence the research is focused on local communities the research selected communities along the river Gambia making the IK identified to be a certain degree limited to those similar geosocial communities hence they are of similar livelihood.

6.5 Recommendations for further studies

This study has provided key insights into the role of IK in flood risk management, flood risk areas, the impact of floods in the communities, and the perception of the local people to climate change. It has simultaneously identified areas for further studies.

In the case of the role of IK in flood risk management, the study confirmed the importance of IK as an approach to mitigate flood risk in The Gambia. However, creating an integrated DRR framework and the extent of integrating the IK into the DRR framework in The Gambia remains an open question. Therefore, it is recommended that research be carried out that will involve policymakers and the local people to come up with a proactive, integrated DRR framework for the country. It is also recommended that priorities be placed on discovering the most effective means of knowledge exchange in the context of IK integration to DRR in The Gambia.

Secondly, hence this study could not prove the extent to which IK as an approach to handling flood risk; there is a need for further research by quantifying the impact of IK in flood risk management by developing a hydrodynamic flood model and testing how different combinations of IK in flood will help mitigate flood hazard in The Gambia. This type of study could serve as an evident building tool that could help build a more robust flood risk management system in The Gambia.

In addition, given that this study highlighted the insufficiency and ineffectiveness of the local communities' method of flood risk management, there is a strong need for longitudinal research where shareholders (Government and NGOs) and academia will collaborate to find a sustainable and integrated flood risk management strategy for the country.

The Gambia like many coastal and low-lying countries, faces increasing threats from climate-related hazards. The buffer zone shown in this research may not remain sufficient in the coming decades in the absence of intervention, thus adjustments in GIS models might be needed to accommodate more detail and larger buffer zones to predict future flood risk in The Gambia.

Furthermore, there is a need for research to be conducted to explore the impact of climate change on the reliability of IK and its implications for future disaster preparedness. This will help in providing a national valuable flood management and adaptation strategy in an evolving climate change-induced disaster.

Moreover, further studies should expand the geographical scope by including other neighbouring countries to The Gambia. This will help to provide a more comprehensive understanding of flood risk across the subregion.

As there is a need for gender-specific research on the experience of female-headed households and other marginalized groups, community engagement and education initiatives should be promoted to improve the use and preservation of IK. For this reason, much effort should be made to improve the availability of quality data related to flood risk assessment and documenting IK related to DRR and climate change adaptation in the country.

6.6 Recommendations for A Locally Adapted Early Warning System (EWS)

- To establish community-based Alert Committees (CBACs) in all flood-prone communities where the local volunteers are trained to serve as a focal point for early warnings.
- To conduct regular drills and awareness campaigns using local materials in local languages
- to combine traditional forecasting indicators (e.g., Meteorological, Riverine, Ecological, Celestial) by the local people with the scientific forecasts from The Gambia Meteorological Department (GMet) and the National Disaster Management Agency (NDMA).
- There is a need to translate the scientific data into a simplified visual format (e.g., colour-coded flood risk maps) that will be locally understood by the residents.
- Implement local regular training programmes on climate risk communication, community-based flood management, and the emergency response thus with the aim of reaching low-literacy residents.

6.7 Proposed Ways to Fast-track Globalisation of IK

To fast-track the use of IK in The Gambia and globally, I proposed the following key strategies based on insights from this thesis.

Institutionalisation of IK in policy Planning:

- Governments, international organisations, and relevant stakeholders should endeavor to integrate IK into their formal climate adaptation policies together with scientific approaches.
- There should be well-developed regional and global guidelines to standardise the approach documentation and IK application in the field of climate change adaptation.
- There is a need to establish a legislative framework that will help to recognise and preserve IK as a vital component of climate resilience.

Strengthening Community Participation in Climate Change Decision-Making:

- Communities should be provided with capacity-building programmes for them to be able to document and apply IK effectively in their communities.
- To promote co-governance models where local communities are key stakeholders in shaping climate change adaptation policies.
- To develop community-led research initiatives where they a funded to promote local innovations.

Bridging IK with Science and Innovation:

- Encouraging and supporting transdisciplinary research with IK with modern climate science with the aim of enhancing credibility and scalability.
- To leverage remote sensing and GIS to validate and guide traditional climate resilience strategies in our local communities.
- To fund and encourage pilot projects that will test the IK solutions in ecological and socio-economic settings.

Creating knowledge exchange platforms:

- There is a need to organise international conferences and workshops for IK holders to collaborate with policymakers and scientists.

- To create digital IK repositories (e.g., open access databases, mobile apps) that will allow local communities globally to share successful IK -based climate change adaptation strategies.
- To establish regional IK knowledge hubs that can help to facilitate cross-community learning and adaptation strategies.

Raising awareness and changing perceptions:

- To conduct global and local advocacy campaigns to have a paradigm shift in perceptions of IK being an outdated approach to climate change adaptation.
- To ensure that IK is integrated into academic curricula thus educating scientists, planners, and policymakers.
- Utilising storytelling and media (e.g. podcasts, community radio, documentation) to promote successful IK application in the field of climate change.

By implementing these strategies, IK can be transformed from being localised practices into a globally recognised and widely adopted climate change adaptation mechanism.

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Appendix 1. Focus Group Discussion (FGD) Guide

<table>
<tr><th colspan="2">Introduction</th></tr>
<tr><td colspan="2">Introductory statement
Welcome, and thank you for agreeing to be part of today's focus group discussion. We appreciate your willingness to participate and the time you have taken out of your day to take part. I am very glad.

My name is Edward Mendy and I am from Brikama a Ph.D. student under WASACAL DRP-Climate Change and Disaster Risk Management in Togo. I am conducting these discussions with you members of this community who have experienced a flood. I aim to know your indigenous knowledge in adapting to flood hazards in your community. I will like to know how this knowledge is relevant to your existence in this community.

First, please I would like to cover some general guidelines for us on how this discussion will run:
1. I would like you all to do the talking and to hear from everyone in the group.
2. Only one person should speak at a time so please we should wait for the person talking to finish.
3. There are no right or wrong answers – every person's opinion and view are important and we would like tohear a range of different views.
4. Anything discussed in this gathering remains in this place. I want everyone to feel comfortable discussing any issue related to the topic.
5. I will be recording these discussions because we want to capture everything you have to say accurately.But please be assured that I do not identify anyone by name in any report and your identity will remain anonymous.
6. Does anyone have any questions?</td></tr>
<tr><td>Explore participant backgroundinformation</td><td>Now I would like everyone to introduce themselves. Can you please tell us your name, age, occupation if any, and for how long you have been in this community?</td></tr>
</table>

Topics to address in this FGD guide:

- Investigate a brief impact of the flood on their community
- Explore the indigenous knowledge in pre-flood preparation
- Explore the indigenous knowledge during flood events
- Explore the indigenous knowledge during post-flood in their community.

Type of Activity/ Themes / Topics	**Questions**
General Question	Is there any indigenous knowledge in the area of flood? Where did you get them from or who give them to you? Did you think that knowledge is of great help to you now?

Investigate a brief impact of flood in their community	When a flood occurs, what are some of the damages it courses in your households? Did you believe that flood can cause retarded growth in your community?
Explore the indigenous knowledge in pre-flood preparation	How did you predict the flood? Signs? What did you think is the cause of the flood in your area? What did you do in preparation for a flood?
Explore the indigenous knowledge during flood events	How did you cope with a flood? Is there any sign to inform the people in the community to evacuate during a flood? Where do you stay during a flood?
Explore the indigenous knowledge during post-flood in their community.	After the flood, what did you do? Are there any signs to say that the flood will stop at a particular time? How did you keep a record of flood events in your community?

Appendix 2: Survey Questionnaire

Dear respondent, my name is Edward Mandy, a Ph.D. student under WASCAL DRP-Climate Change and Disaster Risk Management at Universites de Lome. I am currently working on my Doctoral Thesis Research (Assessment of Flood Risks and Indigenous Knowledge employed in Flood management Along The River Gambia**)** but in this questionnaire, I aim to address the objective of **"assessing the flood vulnerability and impact in communities along the River Gambia".** This survey might not take you more than 30 minutes.

Your participation is entirely voluntary, and all information collected in this survey will be kept strictly confidential and anonymous. The information gathered will only be used for academic purposes. You have the right to refuse to answer any questions/items or to avoid participating at any time for any reason. Thank you for giving your valuable time to complete the following survey questionnaire**.**

Name of the respondent …………………………………………… Questionnaire No:…………

1.0	**GENERAL INFORMATION**	
1.1	Date of interview	
1.2	Name of Region	
1.3	Name of District	
1.4	Name of Community	
2.0	**DEMOGRAPHIC CHARACTERISTICS**	
2.1	Gender	1. Male [ ] 2. Female [ ]

2.2	Age (years)	1. 20-29 [ ] 2. 30-39 [ ] 3. 40-49 [ ] 4. 50-59 [ ] 5. 60 and above [ ]
2.3	Ethnic group	1. Mandinka [ ] 2. Wolof [ ] 3. Fula [ ] 4. Others (specify) [ ]
2.4	Religion	1. Islam [ ] 2. Christianity [ ]
2.5	Marital status	1. Married [ ] 2. Single [ ] 3. Widowed [ ] 4. Divorced [ ]
2.6	Highest level of education	1. Primary [ ] 2. Secondary [ ] 3. Tertiary/University [ ] 4. Informal/Madarasa [ ] 5. NA [ ]
2.7	Occupation	1. Civil Servant [ ] 2. Farmer [ ] 3. Trader [ ] 4. Others, Specify ………………………..
2.8	Settlement Type	1. Rural [ ] 2. Urban [ ]
2.9	Household Size	1. 5 below [ ] 2. 6 – 10 [ ] 3. 11 -20 [ ] 4. 20 and above [ ]
3.0	**SOCIO-ECONOMIC INFORMATION**	
3.1	How long have you resided in this community? In Years…	1. 5 below [ ] 2. 6 – 10 [ ] 3. 11 – 15 [ ] 4. 16 – 20 [ ] 5. 20 and above [ ]
3.2	What material is the wall of your house made with?	1. Wood [ ] 2. Iron sheets [ ] 3. Mud [ ] 4. Mud blocks [ ] 5. Fired bricks [ ] 6. Cement block [ ] 7. Others (specify) …………………….. [ ]
3.3	What material is the roof of your house made with?	1. Thatch 2. Iron sheet 3. roof tiles

		4. Others (specify) …………………….. [ ]
3.4	What is the material covering the floor of your house?	1. Mud/dung [ ] 2. Cement/concrete [ ] 3. tiles [ ] 4. Carpet [ ] 5. Others (specify) …………………….. [ ]
3.5	Does your household have access to electricity?	1. Yes [ ] 2. No [ ]
3.6	If YES, from which sources?	1. NEWEC [ ] 2. Solar Panel [ ] 3. Others (specify) …………………….. [ ]
3.7	What is the main source of drinking water for your house?	1. Public tap [ ] 2. Borehole [ ] 3. Covered dug well [ ] 4. Uncovered dug well [ ] 5. Rainwater [ ] 6. River [ ] 7. Other specify.. [ ]
3.8	Do you treat your water in any way to make it safer to drink?	1. Yes [ ] 2. No [ ]
3.9	How do you treat your water?	1. Boil [ ] 2. Add bleach [ ] 3. Strain it through a cloth [ ] 4. Sedimentation [ ] 5. Other specify.. [ ]
3.10	What kind of toilet facility do members of your household use?	Flush Toilet [ ] Pit latrine [ ] Open defecation [ ] Other specify.. [ ]
3.11	Does this household have a functional radio?	1. Yes [ ] 2. No [ ]
3.12	If YES, have you ever listened to a program related to climate change and its impacts?	1. Yes [ ] 2. No [ ]
3.13	Does this household have a functional television?	1. Yes [ ] 2. No [ ]
3.14	If YES, have you ever watched to a program related to climate change and its impacts?	1. Yes [ ] 2. No [ ]
3.15	Does this household have a mobile phone in working condition?	1. Yes [ ] 2. No [ ]
3.16	If yes have you ever used your mobile phone to find out about safety issues and to alert people?	1. Yes [ ] 2. No [ ]

3.17	If **YES**, have you ever used your mobile phone to contact police, medical emergency, or NDMA officials during flooding?	3. Yes [ ] 4. No [ ]
3.18	If **NO** for **# 3.15**, why don't you have a mobile phone?	1. We cannot afford it [ ] 2. Poor mobile network where we live [ ] 3. No electricity at home to charge it [ ] 4. My phone is broken [ ] 5. Other specify.. [ ]
3.19	Do you have access to flood maps?	1. Yes [ ] 2. No [ ]
3.20	Does this household have access to the internet?	1. Yes [ ] 2. No [ ]
3.21	If **YES**, have you obtained any information regarding flood disasters?	1. Yes [ ] 2. No [ ]
3.22	Have you used any institution to insure yourselves (life, health) or property (household goods, house, vehicle, and the like) in the past 12 months?	1. Yes [ ] 2. No [ ]
4.0	**FLOOD IMPACTS AND HOUSEHOLD's COPING STRATEGIES**	
4.1	Has your community ever been flooded?	1. Yes [ ] 2. No [ ]
4.2	If **YES**, how many times has your household experienced a flood in the past 10 years?	1. 1 – 3 [ ] 2. 4 – 6 [ ] 3. 7 – 9 [ ] 4. 10 and above [ ]
4.3	To you what is the main source of floods?	1. Building on flood plains [ ] 2. Too much rain [ ] 3. Clearing of vegetation [ ] 4. Steep slopes [ ] 5. Nature of soil (waterlogged area) [ ] 6. Punishment from God [ ] 7. Lack of drainage system [ ] 8. Lack of proper planning of structures [ ] 9. Others specify ……………………… [ ]
4.4	Please tell us the frequency of floods in your community.	1. Never experienced flood [ ] 2. More than 4 times a year [ ]

		3. 2 - 4 times a year [ ] 4. Once a year [ ]
4.5	What is/are the Impact of flood in your community (multiple responses possible)	1. Damage buildings [ ] 2. Damage roads [ ] 3. Destruction of farms [ ] 4. Death of livestock [ ] 5. Death of human beings [ ] 6. Causes diseases/illnesses of people [ ] 7. Displacement of people [ ] 8. Destruction of electricity infrastructure [ ] 9. Pollution of water sources [ ] 10. Destruction of market [ ] 11. Others specify ……………………… [ ]
4.6	During flood events, how long does the flooding last?	1. Few hours [ ] 2. A day [ ] 3. Less than a week [ ] 4. A week [ ] 5. More than a month [ ]
4.7	Did water enter your building during the last flood?	1. Yes [ ] 2. No [ ]
4.8	If yes, what is the depth of the flood water in your building? Estimate in meters……………	…………………………………………………………………… …………………………………………………………………….
4.9	Do you receive warnings about impending floods?	1. Yes [ ] 2. No [ ]
4.10	If **YES**, from which source?	1. Government agencies 2. community institutions 3. NGOs 4. Friends 5. Media
4.11	Through what means do you get the information about flood?	1. social media (Facebook/WhatsApp etc) [ ] 2. Radio/television [ ] 3. newspapers/magazines [ ]

		4. face to face interaction [ ] 5. Town Crier [ ] 6. Others specify …………………… [ ]
4.12	Please list the assets that were damaged. (**multiple responses possible)**	1. Homestead [ ] 2. Farmlands [ ] 3. Livestock [ ] 4. Crops [ ] 5. Building [ ] 6. Business premises [ ] 7. Produced goods [ ]
4.13	How was the asset affected?	1. Completely damaged [ ] 2. Greatly damaged [ ] 3. Moderately damaged [ ] 4. Very little damaged [ ]
4.14	Estimate the cost of restoration to its status. (in **GMD**)	…………………………………………………………… ………………………………………
4.15	Did you leave your house when it was submerged?	1. Yes [ ] 2. No [ ]
4.16	If '**YES'** where did you go?	1. Elsewhere in the village [ ] 2. to another community [ ] 3. Others specify …………………… [ ]
4.17	If '**NO'** why did you not leave?	Nowhere to go [ ] No means/ vehicle for leaving [ ] Roads were submerged by water [ ] Could not afford the move [ ] Did not consider it enough danger posed [ ] Affinity with ancestral homes [ ]
4.18	Does your household know any safe place (Evacuation center) you could move to during flood events?	1. Yes [ ] 2. No [ ]
4.19	If **YES**, where is that place?	1. School building [ ] 2. Hospital building [ ]

		3. Mosque/ Church [ ] 4. Community square [ ] 5. Another community [ ]
4.20	Are there preparations your household makes beforehand in anticipation of the flood?	1. Yes [ ] 2. No [ ]
4.21	**1.** If yes, what preparations?	……
4.22	Did any member of your household die as a result of the last flood?	1. Yes [ ] 2. No [ ]
4.23	Did any member of your household suffer injury as a result of the last flood?	1. Yes [ ] 2. No [ ]
4.24	Has this household received any training on how to adapt to flood risk?	3. Yes [ ] 4. No [ ]
4.25	Do you consider your coping strategies sufficient?	1. Yes [ ] 2. No [ ]
	Which gender in your perception was more affected by the following issues:	
4.26	Displacement from homes and businesses	1. Male [ ] 2. Female [ ]
4.27	Exposure to disease outbreak	1. Male [ ] 2. Female [ ]
4.28	Poor personal hygiene occasioned by lack of sanitary items	1. Male [ ] 2. Female [ ]
4.29	Existence of cultural beliefs that hinder relocation	3. Male [ ] 4. Female [ ]
4.30	Incidents of Robbery	1. Male [ ] 2. Female [ ]
4.31	Control of property and resources	1. Male [ ] 2. Female [ ]
4.32	Restriction of mobility	1. Male [ ] 2. Female [ ]
4.31	Decision to relocate	1. Male [ ] 2. Female [ ]
4.32	Deaths from flooding	1. Male [ ] 2. Female [ ]
5.0	**THE EFFECTS OF CLIMATE CHANGE VARIATION ON LOCAL COMMUNITIES ALONG THE RIVER GAMBIA**	
5.1	Please look at the following list of environmental issues, and circle the	1. Air pollution [ ] 2. Pollution of rivers and seas [ ]

	two issues that concern you the most. Please only circle two issues from the list:	3. Flooding [ ] 4. Litter [ ] 5. Poor waste management [ ] 6. Traffic/ congestion [ ] 7. Climate change [ ] 8. Extinction of species [ ] 9. Overpopulation (of the earth by humans) [ ]
5.2	Have you heard of "climate change"?	1. Yes [ ] 2. No [ ]
5.3	If YES, What do you know about it?	
5.4	Where have you heard about climate change?	1. Television/ Radio [ ] 2. Newspaper/ Internet [ ] 3. School/ College/ University [ ] 4. Government agencies/ information [ ] 5. Friends/ family [ ] 6. Others specify …………………… [ ]
5.5	How important is the issue of climate change to you personally?	1. Very important [ ] 2. Quite important [ ] 3. Not very important [ ] 4. Not at all important [ ]
5.6	Why is it important to you?	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………
5.7	What do you think causes climate change?	…………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………….
5.8	What impacts, if any, do you think climate change may have?	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………..
5.9	Do you think climate change is something that is affecting or is going to affect you, personally?	1. Yes [ ] 2. No [ ] 3. I don't know [ ]
5.10	If yes, in what way(s) is it affecting you, or is it going to affect you?	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………
5.11	Do you think anything can be done to tackle climate change?	1. Yes [ ] 2. No [ ] 3. I don't know [ ]
5.12	If **YES the question above**, what do you think can be done to tackle climate change?	…………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………

5.13	Have you ever taken, or do you regularly take, any action out of concern for climate change?	1. Yes [ ] 2. No [ ] 3. I don't know [ ]
5.14	If **YES** to the question above, what did you do/ are you doing?	……………………………………………………………… ……………………………………………………………… ……………………………………………………………… ………………………………………………………………
5.15	What are the biophysical changes that have occurred in the last 20 years?	……………………………………………………………… ……………………………………………………………… ……………………………………………………………… ……………………………………………………………....
5.16	When did you first notice that there has been a significant change in climate/weather patterns? (Indicate the decade, e.g. 1980s)	1. 1980s [ ] 2. 1990s [ ] 3. 2000s [ ] 4. 2010s [ ] 5. 2020s [ ]
5.17	How many drought/flood incidences have you witnessed in your lifetime?	(A) Drought incidences: [ ] 1. Less than 3 [ ] 2. 4-6 [ ] 3. More than 6 incidences [ ] 4. Never witnessed [ ] (B) Flood incidences: [ ] 1. less than 3 [ ] 2. 4-6 [ ] 3. More than 6 incidences [ ] 4. Never witnessed [ ]
5.18	In which decade, would you say there have been frequent adverse weather events in this area?	1. 1980s, [ ] 2. 1990s [ ] 3. 2000s [ ] 4. Others specify………………………………….[ ]
5.19	What type of extreme weather events has been common in this area in the last five years?	1. Increased drought incidences [ ] 2. Increased flood incidences [ ] 3. Extreme temperatures [ ] 4. Late rains [ ] 5. Dry spells [ ] 6. Early rains [ ]
5.20	Do you have access to weather forecasting information from meteorology?	1. Yes [ ] 2. No [ ]
5.21	What is the source of this weather forecasting information?	1. Radio/TV [ ] 2. Extension workers [ ] 3. Friends in the village [ ] 4. Household (Family) members [ ] 5. Internet [ ] 6. Other specify…………………………………….. [ ]
5.22	Do you know of any traditional methods/indicators for predicting the weather?	1. Yes [ ] 2. No [ ]

5.23	If YES to the above question, name these indicators/methods used to predict weather patterns	
	Weather Pattern	**Prediction of Weather Pattern**
	Drought Year	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………..
	Normal year (Rainfall)	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………
	Flood Year	…………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………….
	Very cold winters	…………………………………………………………… …………………………………………………………… …………………………………………………………… …………………………………………………………….
	Normal winters	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………...
	Very hot summer	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………..
	Normal summer	…………………………………………………………… …………………………………………………………… …………………………………………………………… ……………………………………………………………
5.24	Over the past five years, when did you experience these extreme weather events?	1. 2018 [ ] 2. 2019 [ ] 3. 2020 [ ] 4. 2021 [ ] 5. 2022 [ ]
5.25	What common damages/ losses do people in this area usually experience due to extreme weather events?	1. Crop damage [ ] 2. Livestock loss [ ] 3. Loss of biodiversity [ ] 4. Scarcity of water [ ] 5. Low yields [ ] 6. Low fish catches [ ] 7. Fishing vessels damage [ ] 8. Others specify……………………………………… [ ]

5.26	What are the observed changes in the rainfall patterns in the last 20- 30 years?	1. No changes [ ] 2. Late onset of season [ ] 3. Early onset of the season [ ] 4. Erratic/random [ ] 5. Poor distribution [ ]
5.27	What are the observed changes in rainfall intensity in the last 20- 30 years?	1. Increasing [ ] 2. Decreasing [ ] 3. No change [ ]
5.28	what is your opinion on the rainfall intensity in the next 10 to 30 years to come?	1. Increasing [ ] 2. Decreasing [ ] 3. No change [ ]

Appendix 3: Research clearance from The Ministry of Higher Education, Research, Science and Technology (MoRST), The Gambia

REPUBLIC OF THE GAMBIA

MINISTRY OF HIGHER EDUCATION, RESEARCH, SCIENCE AND TECHNOLOGY
Opposite Gambia Chamber of Commerce & Industry (GCCI) Building
Senegambia Highway, Bijilo, The Gambia

Ref: AFG 85/272/02
13th December 2022

Mr. Edward Mendy
West Africa Science Service Center (WASCAL)
University of The Gambia,
Brikama Campus, The Gambia

RE: SEEKING CLEARANCE TO CONDUCT A Ph.D. RESEARCH IN THE GAMBIA

Having carefully gone through your Research Proposal on the **"Assessment of Flood Risk and Indigenous Knowledge employed in Flood Management Along the River Gambia"**, we found your initiative welcomed and laudable. This is because it is important to understand the environmental issues, particularly the re-occurrence of flood that are causing serious havoc to our environment and loss of lives at times.

In this way, we understand that:

1. your research will cover five regions and two administrative regions of the Gambia
2. Your research is designed to understand indigenous knowledge of flood risk management and the effect of climate variation on our local communities along the river Gambia.
3. Your research methods of data collection will involve collecting primary data from the communities,
4. Your research will not cause threat to the public but instead add value to higher education capacity building of the Gambia;

Therefore, by the conditions of the authorization issued in connection to the above application, we hope you will apply Standard Operation Procedures to minimize errors. The Research findings will be shared with the Directorate of Research of this Ministry and again we advise that your research processes adhere to the strictest principles of good ethics, originality and best practice in scholarly publishing world. In the light of the above, and in consideration of the approach you intend to carry out your proposed research, and the benefit it will bring to The Gambia, we are happy to give you a clearance to carry out your research.

…………………

James Gomez
For: Permanent Secretary

RECEIVED
15 DEC 2022

Tel: 220 446 5405/220 446 5404 email: info@moherst.gov.gm