



RESEARCH PAPER

Factors Impeding Comprehension and Inclusion of Early Warning Messages in Kolwa East Ward, Kisumu County, Kenya



Photo: Kenya Red Cross Society

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Abstract

The early warning systems (EWS) are vital components of disaster risk reduction strategies, offering cost-effective solutions to minimize the damage caused by flood disasters. Kenya experiences floods annually resulting in displacement food insecurity, and economic hardships of the affected communities. A people centred EWS will be essential to reducing losses and damages caused by floods. This study explored why early warnings doesn't result into an emergency response from the community at risk. The study investigated the barriers to EWS and factors impeding their comprehension and inclusivity. Qualitative research methods were used to conduct the study, key informant interviews and onsite focus group discussions and were conducted at the ward level. Based on our findings, we recommend the need for involvement of all stakeholders in developing and disseminating the EW messages. There is need for integration of indigenous knowledge so as to improve the reliability and usability of the forecasts. The EW messages should be timely and incorporate the needs of the marginalized and vulnerable communities to ensure translation of the messages into disaster preparedness and action. Lastly, there is need for improved governance structure of flood management at the national and county level so as to improve the response capacity of the government.

Key words: Early Warning Systems, Disaster response and preparedness, Floods, Last mile Community

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Global Disaster
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Acronyms and Abbreviations

CFF	Critical Failure Factors
CIDP	County Integrated Development Plan
EW	Early warning
EWM	Early warning messages
EWS	Early warning systems
FEWS	Flood Early warning systems
FEWER	Flood Early Warning Early Response
IK	Indigenous knowledge
KMD	Kenya Meteorological Department
SMS	Short message service
USD	United States Dollar
WRA	Water Resources Authority

1. Introduction

Extreme weather events have gained prominence due to their escalating severity and frequency, substantially disrupting socio-economic activities worldwide (Bompotas *et al.*, 2022; Dube *et al.*, 2022; Seneviratne *et al.*, 2021). Increased weather events including heavy rainfall events and heatwaves are projected to occur in the future given worsening climate change. Investments in early warning systems (EWS) is one of the adaptation strategies that has been adopted globally to reduce or avoid the damages and deaths attributed to weather-related hazards (New *et al.*, 2022). According to the International Strategy for Disaster Reduction, early warning entails providing information effectively and on time using recognized institutions, thus allowing persons vulnerable to hazards to act to reduce or avoid risk and prepare for effective response (UNISDR, 2004). The Sendai Framework for Disaster Risk Reduction 2015–2030, promotes EWS as crucial for addressing climate risks and enhancing access to early warnings to enhance "the availability and access to multi-hazard early warning systems" (UNISDR, 2015).

An efficient EWS can significantly reduce risks associated with natural hazards; it detects and forecasts looming catastrophic events, allowing warnings to be developed based on scientific information, monitoring, and evaluation of the elements that determine the intensity and frequency of disasters (Lumbroso, 2018). In addition, the 2016 Paris Agreement supports the use of EWS for adaptation and risk reduction (United Nations, 2015). Early warning is a vital tool for the prevention of disasters and preparedness for threats and hazards of all types as well as enhancing disaster risk reduction (IFRC, 2012). For example, in Europe investing in the European Flood Early Warning Systems (FEWS), can yield significant economic benefits i.e. 400 Euros return for every Euro invested (Pappenberger *et al.*, 2015). Studies show that FEWS can save households significant amounts of money during disasters. However, developing countries still need to prioritize and improve their EWS to effectively mitigate risks and protect communities.

A study on the cost-effectiveness of FEWS conducted in Bangladesh revealed that families thought the FEWS was beneficial and reliable thus aiding them to protect domestic resources, livestock, and agricultural expenditures worth USD 2525.59 per family (Islam *et al.*, 2024). In 2010, Pakistan experienced severe floods that caused economic losses valued at \$10 billion, devastated over 2 million hectares of crops, and affected 24 million individuals. The 2022 floods which were the worst floods ever experienced afflicted 33 million people, surpassing the 20 million impacted by the floods that occurred in 2010. The greater effect of the 2022 floods underscores the critical need for ongoing monitoring, preparedness, and response efforts to reduce future disaster hazards (Shah *et al.*, 2018).

Recent flood events have exposed the lack of coordination between early warning providers and emergency responders, resulting in significant damages. Flood events that occurred in June 2021 in Germany (Thieken *et al.*, 2023; Payet and Forestier, 2021), New York (Hanchey *et al.*, 2021; Kozlov, 2021), and in Pakistan in 2022 (Bhutta *et al.*, 2022; Wyns, 2022) are some recent examples of the many failures of EWS. In these examples, the failure of EWS was attributed to the inadequate institutional governance, custodianships, and coordination which are critical to the success of EWS. These examples underscore the need for scholars to examine the connection between the failure of EWS and their underlying causes.

Floods are caused by natural events such as flash floods, river overflows, and coastal flooding exacerbated by human activities like deforestation, encroachment of riparian areas, and land degradation for instance, floods have occurred in river basins even during regular rainfall due to increased surface runoff caused by deforestation and land degradation in upstream areas (Aldardasawi and Eren, 2021). Floods have a significant environmental impact worldwide, with coastal megacities in developing nations particularly at risk due to weak flood management capacity (Niang *et al.*, 2014; Ogie *et al.*, 2020). The World Health Organization estimates that floods have affected over two billion people globally, causing over one million deaths and economic losses of USD 80 billion (WHO, 2024; WMO, 2021). Extensive impact due to climate change has been felt globally in all political, social and economic activities thus disrupting the way of life of people tremendously (Bergquist *et al.*, 2019). Mounting disaster risks have increased the vulnerability of not only households but also ecological systems and communities as well (Prior and Eriksen, 2013).

Despite recognition of the significance of EWS, its comprehension and inclusion in developing countries, like Kenya, remain critically deficient, necessitating an exploration of underlying factors. According to the Index for Risk Management (INFORM) model 2018, Kenya is susceptible to natural and human-inflicted hazards compared to her neighbors such as Tanzania, Ethiopia, and Uganda. Among the 47 counties of Kenya, Kisumu County situated on Lake Victoria, is particularly vulnerable to climate change impacts such as floods, high temperatures, and drought. (County Government of Kisumu, 2023b, 2023a; Okayo *et al.*, 2015). With a poverty rate of 60%, the County lacks adequate coping mechanisms, resulting in significant loss of life and economic impacts. Effective EWS is crucial in addressing these challenges (County Government of Kisumu, 2023b). Extreme climate events cause significant loss of life and adversely affect the national economy (GOK, 2021).

Flood losses in Kano plains of Kisumu County were estimated at USD 850,000 annually with relief needs totaling USD 600,000 (Masese *et al.*, 2016). The 2020 floods in Kenya

displaced 350,000 people, caused 230 deaths, and affected 800,000 people leading to cholera outbreaks in five counties (UNICEF, 2018). The response efforts cost the Government of Kenya USD 1 billion (GOK, 2019). In April 2024, floods in Kolwa Central displaced 600 families, and 725 families were affected in Kisumu West and Kisumu East. While River Nyando flooding led to displacement and loss of livestock, crops and material possessions for 2,700 households (Floodlist, 2024). Despite the significance of FEWS, its coverage in Africa falls behind that of other regions globally (Lumbroso *et al.*, 2016; WMO, 2020). According to Islam *et al.* (2024), as the confidence of the communities in FEWS grows and the lead times are enhanced, FEWS progressively changes their behavior over time leading to enhanced social capital and a wider range of early interventions that reduce preventable damage and loss. The extension of the forecast lead time by two days has the potential to increase savings by 21.7 times (Islam *et al.*, 2024).

This study interrogated the social, institutional, and policy barriers in accessing early warning messages and factors impeding comprehension and inclusivity of early warning messages on the last mile community in Kolwa East, Kisumu County. Despite recognition of the significance of EWS, its comprehension and inclusion in developing countries, like Kenya, remain critically deficient, necessitating an examination of the underlying factors. Last mile communities can take disaster preparedness actions in good time if they have access to FEWS, are involved in the development of these systems as well as the dissemination of the EWM thereby minimizing loss and damage from floods.

2. Literature Review

2.1. Early Warning Systems (EWS)

The United Nations office for Disaster Risk Reduction (UNISDR) defines early warning system as "the set capacities needed to generate and disseminate timely and meaningful warning information that enables at risk individuals, communities or organizations to prepare and act appropriately and in sufficient time to reduce harm or loss" (UNISDR, 2009). An effective end-to-end EWS that is people centred is comprised of: "Knowledge of the disaster risk, Detection, monitoring, analysis and forecasting of hazards and possible consequences, Communication and broadcasting warnings and, Preparedness at all levels to respond to warnings received" (Perera, Seidou, *et al.*, 2020).

A Flood Early Warning System (FEWS) is designed to produce and broadcast timely and relevant warning information, allowing at-risk organizations, communities and individuals

to prepare and take appropriate action in good time to minimize loss or harm from floods. FEWS serve as a common platform that integrates disaster risk reduction efforts, effective humanitarian interventions, and climate-resilient, sustainable development, addressing both current and emerging flood-related risks (Kiptum *et al.*, 2023). FEWS is not merely a prediction tool; it is a comprehensive system composed of four essential components: “Risk Knowledge, Monitoring and Forecasting, Warning Dissemination, and Preparedness and Response Capacity” (United Nations, 2006; United Nations Office for Disaster Risk Reduction and World Meteorological Organization, 2023).

"A forecast or warning is only of value if the recipient of that information understands it and takes the right action" (Frost, 2023). Therefore, early warning alone does not prevent disasters, but early action is also necessary to mitigate the impact (UNDRR, 2007).

2.2. Barriers to accessing early warning messages

A review by Samansiri *et al.* (2023) listed twenty-four critical factors hindering the effective execution of Flood Early Warning Early Response (FEWER). These factors were classified into 3 categories; (i) factors related to the authorities responsible for generating forecasts and managing the warning systems (generation side), (ii) factors pertaining to the recipients or users of the warnings (receiver side), and (iii) factors linked to supporting tools and technology for generation and dissemination of EWS. Based on this classification, the Critical Failure Factors (CFFs) are broadly divided into three categories: institutional, social, and technical.

Institutional factors that cause a barrier to early warning information include weak institutional governance, coordination and custodianship, lack of proper leadership in institutions and inadequate political will, lack of funds to operate, modernize and sustain FEWER systems, lack of funding to obtain qualified human resources, lack of information and cognizance of key stakeholders and issues in data sharing and data governance (Moisès and Kunguma, 2023; Kumar *et al.*, 2020; Perera, Seidou, *et al.*, 2020) Perera *et al.*, 2019). In addition, poor communication and coordination between agencies and weak policies in the implementation of EWS affect the effectiveness of flood EWM (Moisès and Kunguma, 2023; Kumar *et al.*, 2020). Also identified as institutional barriers to flood early warning system and response are: lack of access to early warning information due to poor transmission or poor mobile network cover (Parker *et al.*, 2009), lack of inclusivity of vulnerable groups and the communities in process of planning the

early warning response and decision making, inadequate preparation at the local level to respond to the warning (Samansiri *et al.*, 2023).

Technical barriers affecting EWM include a short lead time (the time interval between a flood warning and emergency response) due to inadequacies in technology (Northfield *et al.*, 2021; Parker *et al.*, 2009), unavailability of data or poor-quality data arising from technical issues, poor data communication between interrelated system agencies dealing with early warning (Kumar *et al.*, 2020; Perera, Seidou, *et al.*, 2020; Perera *et al.*, 2019; Aguirre *et al.*, 2018) and a lack of capability by the community to receive EWM. Also reported as technical barriers was lack of understanding, wholeness and relevance of flood EWM at the community level, and lack of regulation mechanisms and controls e.g. operating plans or procedure (Moisès and Kunguma, 2023; Northfield *et al.*, 2021; Perera *et al.*, 2019). Social factors include poor community participation in flood early warning and response process (Rana *et al.*, 2021; Perera, Seidou, *et al.*, 2020), lack of public awareness to foster the understanding of the early warning information, lack of credibility and public trust, poor public interest and cultivated culture of neglect (Rana *et al.*, 2021; Perera, Agnihotri, *et al.*, 2020; Perera, Seidou, *et al.*, 2020; Kreibich *et al.*, 2016;), incorrect perceptions of risk and inadequate knowledge of probable and imminent disasters (Perera, Seidou, *et al.*, 2020; Dutta and Basnayake, 2018).

A study by Perera *et al.* (2019) categorized the challenges faced by FEWS into technical, financial, social, and institutional challenges. Technical challenges are faced at the national level, regional level and at the local level. The challenges are inadequate technology, insufficient and poorly managed hydrological networks, lack of technical expertise and manpower. The study established that these technical issues encountered by operational systems translate to challenges in finances such as lack of funds to upgrade or advance EWS, inadequate recruitment and training of personnel and discontinued operation of warning systems. Institutional challenges identified in the study include poor coordination between institutions generating early warnings and agencies mandated to communicate EWM to the public, and ineffective data dissemination between multiple agencies.

Social challenges reported in the report found that that for maximum mitigation of losses, communities at risk need to have sufficient infrastructure to receive EWM. They reported that the intended recipient communities do not have the technology required to receive EWM especially the poor and vulnerable who lack basic amenities. Low literacy rates in highly vulnerable communities presented a barrier to early warning information (Perera *et al.*, 2019). This survey further found that even when an early warning is conveyed, it's not regarded. Only 52% of the research respondents found flood alerts credible enough to respond. The community sampled reported lack of

knowledge about the mandate and role of different agencies, and a lack of awareness of the risk posed or warning response plans during emergencies. This they noted was as a result of ineffective strategies and irregular organizational awareness programs. Notably, a low response to early warnings is heightened when the community living in the target area is made up of a high population of elderly people or children who are not aware of risk posed by the disaster and depend on other community members to make decisions for them or assist in response (Perera *et al.* 2019).

A study by Perera, Seidou, et al. (2020) identified challenges of traditional FEWS and categorized them into: challenges arising from disaster risk knowledge, detection and monitoring, data analysis, forecasting, early warning response and preparedness, and how early warning are communicated and disseminated. The study revealed that when flood EWM is disseminated, it does not automatically reach all people that are at risk of experiencing floods, and sometimes the EWM also fails to reach the intended stakeholders, at the right time and in the correct format. This may be due to inaccessibility to television, radio, or mobile phone through which early warning message is broadcasted, power outages, limitations in broadcasting/mobile network coverage, and limited knowledge of using technology e.g. websites and reading short message service (SMS). The authors observed that even when early warning information is received, many persons in the community fail to act on the EWM due to inadequate information and understanding of the early warning.

Often the delivered EWM is incomplete due to lack of standardized terminologies, standards and procedures for issuing the early warning. When a flood warning is not tailored to the local community's interest, needs and values it may fail to activate the intended responsive action. This could involve the usage of the local dialect and terms that enables easy understanding by the recipient and contains a tailored course of action that is appropriate for that community/recipient (Perera, Seidou, *et al.*, 2020). According to a report by the International Federation of Red Cross and Red Crescent Society dubbed Community Early Warning Systems (Guiding Principles 2012); Early warning information is often ignored based on myths held by the community and even myths held by professionals in disaster risk reduction or management. The report found that these myths provide a false sense of hope or deterred someone from taking action when faced with danger. These myths are a barrier to effective EWM and if these myths are not dispelled, they limit the effectiveness of EWS (IFRC, 2012). The Red Cross dispelled this myth and found that EWM from multiple sources helped people to triangulate and confirm EWM hence increasing the messages' credibility. They recommended that there is a need to repeatedly send out early warnings since the more the warning is heard, the more likely the message will be regarded as credible hence believed and acted upon (IFRC, 2012).

A study by International Centre for Humanitarian Affairs (ICHA) identified insufficient structures and policies, inadequate access to EW information and inadequate capacity to interpret EW information as challenges faced in communication of EW messages. Technical personnel highlighted the importance of enhancing disaster policy and funding mechanisms in order to strengthen disaster preparedness; there was need to improve communication of EW messages through centralization of communication and enhancement of structures and the need for capacity building of stakeholders to enhance their understanding, interpretation and use of EW information so as to enable the stakeholders implement preparedness action based on contextualised and relevant information (ICHA, 2021).

In Hammood et al. (2020), the authors identified the 16 most impactful factors influencing the effectiveness of FEWS, selected from a pool of 66 factors, after reviewing 40 studies. These key factors include system quality, information quality, user satisfaction, service quality, usage, perceived usefulness, intention to use, net benefits, perceived ease of use, compatibility, user experience, relative advantage, complexity, perceived risks, educational quality, and confirmation. While in a study from Pakistan, the authors propose that the success of early warning (EW) systems hinges on several critical factors, including the availability of resources to maintain system functionality, trust of the community, and clear guidelines for disseminating warnings (Rana *et al.*, 2021). Researchers have emphasized that the effectiveness of FEWS is largely hindered by inadequate coordination and communication between agencies (Hammood *et al.*, 2020; Perera, Seidou, *et al.*, 2020; Perera *et al.*, 2019), as well as poor governance in the EWS (Moisés and Kunguma, 2023; Kumar *et al.*, 2020)(Moisés and Kunguma, 2023; Kumar *et al.*, 2020;).

In a study conducted by Okayo et al. (2015) in Kano Plains, Kisumu County, the authors identified social and economic characteristics of the community that determines the community's ability to comprehend flood related early warning information to mitigate the impact of flooding. Characteristics such as the household composition, household income, distance, the occupation of the household members, and the kind of social circle that someone belonged to determine the level of uptake of early warning messages. They concluded that culture affects people's norms and assumptions. Only a negligible percentage of the community was prepared to take action to mitigate the floods for instance to move to higher ground. The researchers noted that if the community or government adopted an attitude of resignation and a "wait and see" culture when dealing with disasters then there will be a buildup of disaster related emergencies in Kenya as occurrence of flooding cases increases (Okayo *et al.*, 2015).

A performance audit report on Kenya's response to floods (2023) showed that early warning messages including flood related early warning information was released by the two government agencies: the Kenya meteorological department (KMD) and the Water Resources Authority (WRA). The audit however noted that there was lack of early warning action by the government as well as the community was missing despite dissemination of EWM. The report further revealed that Kenya lacked a focal national government entity to spearhead flood management, it also noted critical laws and policies on flood management were lacking. The report states that Kisumu County has enacted disaster risk management but had no policies on the same. Flood victims are often left to recover on their own with no assistance from the government thereby making them vulnerable to future flooding (Office of the Auditor General, 2023).

2.3. Factors impeding comprehension and inclusivity of early warning messages

Natural hazards EWS are grounded on strong technical and scientific principles. However, it is crucial to prioritize at risk individuals and adopt a systems approach that takes all key risk factors into account. A FEWS that is focused on people is more effective in communicating risk and saving lives during emergencies (Shah *et al.*, 2022a). It is essential to ensure that at-risk populations receive warnings in a timely manner, giving them adequate time to implement the required actions to protect themselves (Coughlan de Perez *et al.*, 2022).

To enable the local community, take disaster preparedness actions, EW information should be disseminated on time and in a local language to ease understanding. Channels such as SMS and radio should be used; these are easily accessible by the community (ICHA, 2021). A study conducted in Bangladesh revealed that despite the Government sending early warning messages on rainfall and floods through the television and radio, the community's acceptance to these messages was low. Instead of relying on the forecasts sent by the Government, the community opted to depend on their own experiences concerning rainfall and flood in some areas. Since the people don't trust the early warning messages disseminated through television and radio, they may not take adequate disaster preparedness actions thus leading to flood damage (Fakhruddin *et al.*, 2015). This points to the need for the inclusion of the community in preparing and disseminating the early warning messages so that they can trust the information and use it in disaster preparedness.

Tailored warnings are especially crucial for uneducated individuals in remote, flood-prone areas, as they may struggle to comprehend and respond to generalized warnings. In countries where many dialects are spoken at national, state, and local levels, it is essential to translate warnings to suit the at-risk targeted group to ensure they are understood. Equally, warnings specific to a targeted community are crucial for promoting gender inclusion in flood-prone areas of developing countries. Technical jargon and the formal language often used by broadcasting institutions can make it hard for uneducated women to grasp the messages. For instance, focus group discussions in Pakistan discovered that illiterate women in some communities speaking Punjabi struggled to comprehend warnings that referenced statistics such as flood probabilities or millimetres of rainfall, and the formal language of Urdu used on television (Mustafa *et al.*, 2015).

2.4. Effects of the flood on the community

Developing countries are increasingly vulnerable to climate hazards due to more frequent and intense natural disasters (IPCC, 2014). Floods have a significant environmental impact worldwide, with coastal megacities in developing nations particularly at risk due to weak flood management (Niang *et al.*, 2014). Globally, floods are the major prevalent disasters, which has had an effect on over two billion people; caused over one million deaths and financial losses of USD 80 billion (WHO, 2024; WMO, 2021). Yet developing countries are increasingly vulnerable to climate hazards due to more frequent and intense natural hazards (IPCC, 2014; Shah *et al.*, 2022b).

Extreme climate events such as floods and droughts cause detrimental effect on virtually all social and economic actions and are quite rampant in various parts of Africa. Flooding causes inundation of villages, farms, disruption of transport network thereby affecting market distribution as well as food systems.

Floods are one of the most common events that result in severe and long-lasting social and economic consequences worldwide. (Opere, 2013; Speis *et al.*, 2019). Floods are experienced when riverbanks overflow and can cause huge damages to crops, property, infrastructure and loss of life. Floods are brief events that can occur unexpectedly, often with little or no warning. They are typically triggered by intense storms that generate more runoff than the ground can absorb or a stream can handle within its usual channel. Additionally, rivers may flood when dams break or landslides temporarily obstruct a channel (Opere, 2013). According to research done by CRED and UNISDR (2015), on epidemiology of disasters, the most prevalent disaster type was floods which scored 43% (3062 occurrences) and over the past two decades, floods have caused 157,000

deaths worldwide. In addition, 2.3 billion people were affected by 3062 flood occurrences between 1995 – 2015, thereby accounting for 56% of people who have been affected by weather related disasters (Flood list, 2016). Floods causes both short and long-term psychosocial impact such as depression, trauma, anxiety and posttraumatic stress from the flooding effects (Odero and Mahiri, 2022; Speis *et al.*, 2019). Flooding aggravates the affected community economic status given the loss of their livelihood's activities (Odero and Mahiri, 2022).

In Kenya, the hazards and impacts of floods were evident after the 1997/1998 El Nino which led to loss of lives (human and livestock), displacement of people, huge losses to the economy and disruption to the communication network. In addition, these floods caused land degradation in the form of soil erosion, destruction of power lines and silting of hydropower dams (Opere, 2013). The economic impact of flooding in Kenya is estimated to average 0.8% of the country's annual Gross Domestic Product (GDP). However, in years of severe flooding, such as during the 1997–1998 Indian Ocean Dipole/El Niño event, losses can rise significantly, reaching up to 11% of GDP. These losses primarily result from fatalities, damage to infrastructure, agricultural losses (crops and livestock), disruptions, and outbreaks of waterborne and sanitation-related diseases (GOK, 2018).

According to The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) in their flood information (Flash update #6, 17th May 2024) reported that an estimated 291 people in Kenya had been killed by the floods in May 2024 in various parts of the country. One hundred and eighty-eight (188) people were injured, 75 missing while 278380 people (55676 families) had been displaced by floods between March 1 and 16 May 2024 according to the National Disaster Operations Centre. 11311 livestock had been lost, 47578 acres of cropland damaged, 67 roads damaged, 1023 small businesses and 129 schools affected. OCHA reported Kisumu had 14 evacuation camps (one of these was Rweya Primary School located in Kolwa Eastward. (OCHA, 2024).

In addition, floods result in displacement of people and damage to infrastructure. The floods which occurred in 2020 in Kenya, by end of May it had displaced approximately 350,000 people and caused the death of about 230 people, affected 800,000 people and caused cholera outbreaks in five counties (UNICEF, 2018). The response at that time costed the Kenyan Government approximately USD 1 billion (GOK, 2019).

2.5. History of major flood occurrence in Kenya

The 1961 rains in Kenya popularly referred to as '*Uhuru floods*' are remembered as one of the earliest high rains in recent history. It had a devastating effect on existing infrastructure, human lives, livelihood among others. The highest peak discharge on record from Nyando river occurred during 1961-1962 period, which resulted in the flooding of the entire Kano Plains (Raburu *et al.*, 2012).

The *El Nino* associated floods that occurred in 1997/1998 affected various parts of Kenya thus causing loss of lives, waterborne diseases, famine, destruction to property and destruction to infrastructure. Further, private and public property damage worth USD 151.4 million was incurred due to these floods. This estimate doesn't include the number of people who lost their relatives, property, economic opportunities and savings. Extreme climate events such as floods and drought cause adverse effects on all forms of life (Opere, 2013).

The other notable flood events occurred in 1963/1964, 1968, 1977/1978, 1982, 1985, 1990, 1997, 2016, 2019, These floods majorly affected the Lake Victoria basin (Opere, 2013). The floods which occurred during this season was associated with the *El Nino* phenomenon. *El Niño* is a disruption in the ocean-atmosphere system in the tropical Pacific that significantly affects weather patterns worldwide (UNDP, 2004).

3. Methods and Materials

3.1. Study Area

Kisumu County in Kenya, sits at an elevation of 1131m above sea level and is located within the Lake Victoria basin. This study was carried out in Kolwa Eastward, a low-lying flatland between Nandi Hills and Lake Victoria within Kisumu County (Figure 1). Kolwa Eastward located in Kisumu East Sub County is vulnerable to floods annually due to its location on the wetlands by the shores of Lake Victoria. Kenya experiences two seasons - dry (January-February, July-September) and rainy (March-May, October-December). Climate change has made these seasons unpredictable, leading to increased flooding and drought (MoALF, 2017). Kolwa Eastward now faces heavy rains, causing frequent flooding, low agricultural production, food insecurity, poverty, and socio-economic challenges like loss of life, livelihood, and property, waterborne diseases, lack of education, and mental health issues due to climate change impacts.

Kenya has not been spared either from the effects of climate change and has since experienced frequent flooding droughts and high temperatures. Kolwa Eastward faces erratic weather patterns which have caused heavy and prolonged rains resulting into perennial flooding. The harsh weather conditions have translated into low agricultural production thereby causing food insecurity and has brought an increase in poverty levels. The climate risks have result in adverse socio-economic impacts for example deaths, economic losses, increased incidences of waterborne diseases, disrupted education, increased cases of mental distress (Ojina, 2024). Kisumu County has a population of 1,155,574, Kisumu East has a population of 220, 997. (KNBS, 2019). The main economic activities in Kisumu County are fishing, farming and small-scale trade (County Government of Kisumu, 2020).

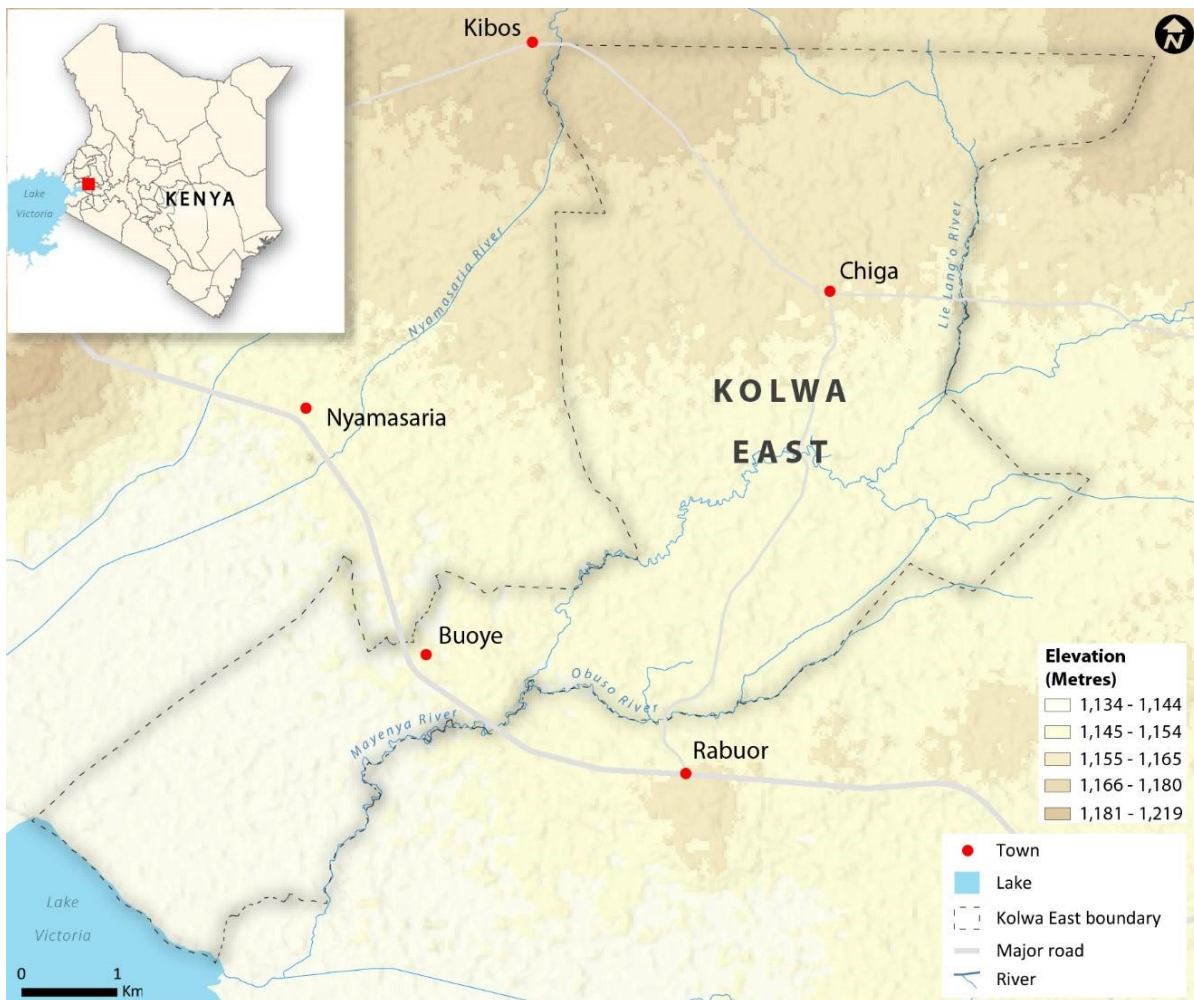


Figure 1: Map of the study area

3.2. Research Design

This study combined GIS and remote sensing techniques to identify the extent of flooding between 2018 and 2024. The flooded areas and vegetation for these seasons were mapped and calculated. In addition, it employed descriptive research design to gather information through interviews and administered questionnaires to the representative sample size. The research design allowed valuable and comprehensive research for quick data collection while maintaining a high degree of confidentiality. We selected the descriptive design selected because it facilitated data collection from respondents across the study area.

3.2.1. Geographical Information System (GIS) and Remote sensing Techniques

Mapping of the flooded area extent relied on data from SENTINEL-1 and LANDSAT data. SENTINEL-1 is an imaging radar mission providing continuous all-weather, day-and-night imagery at C-band. The advantage of utilizing these data over data in the visual range is their ability to provide information even with data collected under cloudy conditions. LANDSAT data was invaluable in selection of training data, and was also used in creating the classification model. A supervised classification approach was adopted and implemented in the Google Earth Engine platform. The approach employed in this study utilized the “random forest algorithm” – a machine learning algorithm - to automatically identify and map flood and flooded vegetation extents from a combination of LANDSAT and SENTINEL-1 data. SENTINEL – 1 and LANDSAT images were selected for the “before” (dry period preceding rains) and “after” (period of peak rainfall) for the March-April-May (MAM) and October-November-December (OND) seasons of 2018, 2019, 2020, 2021, 2022, and 2023.

These were further filtered based on four criteria; spatial extent, Image Mode, Image polarization, and Image spatial resolution. Only images covering Kolwa Eastward, of IW and of Descending mode, of VH polarization, and of 10 metre spatial resolution were selected in the case of SENTINEL-1 and only LANDSAT bands 2, 3, 4, 5, 6, and 7 of similar dates and spatial extent were used. The normalized difference wetness index (NDWI) was calculated for each season of each respective year. NDWI utilizes helps differentiate water from land by capitalizing on the spectral properties of water, which absorbs more infrared and near-infrared light compared to other land cover types;

Training Data Preparation: Training datasets were created by identifying and selecting pixels that represent flood and flooded vegetation, alongside other common land cover classes such as agriculture, urban, permanent water, etc.

Classifier Training: The Random Forest machine learning classifier was trained using the training data prepared. The training process involves learning to distinguish between various cover types based on the spectral and spatial characteristics of the pixels.

Flood Mapping: Once trained, the Random Forest classifier was applied to satellite images to identify the various land cover types alongside flooded areas and flooded vegetation.

The results were exported from Google Earth Engine for further analysis in ArcGIS whereupon they were clipped to the study area and reclassified to visualize only the flood and flooded vegetation areas. The areal extent of floods and flooded vegetation was also calculated within ArcGIS.

3.3. Community Data Sampling procedure

The research study was undertaken in June 24, 2024 to July 3, 2024. Kolwa east was purposively selected as the study area because of its vulnerability to flood and it being a last mile community. The community in Kolwa are the furthest from services, the poverty level is high thus limiting access of the population to services. Kolwa East has a poverty rate of 31.7% (Commission on Revenue Allocation (CRA), 2022). The United Nations Development Program (UNDP) describes that last mile populations as “not only the poorest of the poor, but also the people, places and small enterprise levels that are under-served and excluded, where development needs are greatest, and where resources are most scarce” (UNDP, 2016a).

Stakeholder consultation was done, and data was collected through key informant interviews (KIIs) (table 1) and focus group discussions (FGDs) (table 2). An interview guide was developed for both the FGDs and KIIs to ensure a structured discussion and follow up questions were asked to probe and seek clarification. The questionnaires were piloted and tested before the actual data collection phase.

The study used qualitative methods to collect the data through key informant interviews with key stakeholders. The stakeholders included representatives from county government, national government, local administration, local community, non-governmental organizations, the private sector and civil society groups. Data was

collected using key informant interview (KII) guides and focused group (FGD) (see Annexes I and II). A total of sixteen stakeholders were purposefully selected for the key informant interviews (table 1) while seventy-eight (78) stakeholders were selected for the FGDs (See Table 2). The FGDs were gender disaggregated to ensure that women actively participated in the discussions. The KIIs took about 45 minutes to 1 hour whereas the FGDs took 2 hours. Consent of the interviewees was sought before commencing data collection process; data was collected through audio recording and note taking.

Table 1: Key Informant Interviews

S/No	Government Department	Key Informant Interviews
1.	Department of Agriculture, Irrigation, Livestock and Fisheries	1
2.	Red Cross Officers	2
3.	Community Health Promoter	1
4.	Area Sub Chief, Mahenya	1
5.	Village Elders	2
6.	Youth, Gender and PWD Advisor to Governor, Kisumu County	1
7.	Kenya Meteorological Department (KMD)	1
8.	National Environment Management Authority, Kisumu County	1
9.	Early Childhood Department (Education)	1
10.	Water Resources Authority (WRA)	1
11.	Department of Road, Transport and Public Works	1
12.	Subcounty administrator, Kisumu East	1
13.	Department of Special Programs/Disaster Management	1
14.	Climate Information Services, Climate Change Unit	1
	Total	16

Table 2: Focus Group Discussion

S/No	Focus Group Discussion*	Total Number
1.	Men	1
2.	Women	1
3.	Mixed	2
	Total	4

*Each FGD comprised of between 20 – 25 participants

3.4. Data Collection Procedure

A separate open ended interview schedule was developed for the KIIs and FGDs. The interviews focused on four major themes that is causes and effects of flood, barriers to accessing early warning messages, factors affecting comprehension and inclusivity of early warning messages and Government involvement in early warning. Follow up questions were used by the researchers depending on the responses from the interviewees to probe and gather more information about the respondents' lived experiences; this ensured an in-depth conversation between the researchers and interviewees.

3.5. Data Processing and Analysis

A rigorous process of thematic analysis was used in the data analysis. Data processing and analysis comprised of three steps: Transcription of data (organising and conversion of the data into written texts), exploring of the data and reduction of the data or text through coding (Akinyode and Khan, 2018; Attride-Stirling, 2001; Creswell and Creswell, 2018). The process started with translation in verbatim then transcription from the local language (*dholuo*) to English language of all the audio data collected from the Focus group discussions (FGDs) and key informant interviews (KIIs). All notes gathered through observations and handwritten interview transcriptions were typed. All transcripts were proof read to confirm and ensure accuracy of the data captured; then entered into the Dedoose software for coding and analysis.

Next step was coding. Coding refers to the process of grouping and tagging sections of texts which are related to a specific theme together that is to assign codes or labels to

data for subsequent analysis (Creswell, 2013). Data was distilled into smaller meaningful parts or categories; and labelled with a descriptive title to form a code. The information was then grouped by thematic structure or similarity to form a code. Data coding and analysis was carried out by a team of researchers. The coding team identified excerpts from the transcripts that were relevant to each research question and coded them using the codebook generated. Finally, the study team identified emerging themes and patterns in the data.

The research team identified seven broad thematic areas as follow.

- a. Knowledge of the climate risk
- b. Climate change effects
- c. EW awareness
- d. Communication and dissemination of EW messages
- e. Community involvement in flood management
- f. Disaster response capacity of county government
- g. Marginalized, vulnerable groups and gender integration

Table 3: Parent and Child Codes

Parent code	Child codes
Knowledge of the climate risk	Causes of floods
	Duration of floods
	Frequency of floods
Climate change effects	Effects of climate change to community
	Awareness of laws/policies
EW awareness	Awareness of EWS and EWM
Communication and dissemination of EW messages	Access to weather forecasting data - county
	Accuracy of warnings received

	Content of EWM (extend of flood, evacuation, amount of rain)
	Effective dissemination channels
	How EWM are received
	Indigenous knowledge
	Language and understanding
	Timing of messaging
	Whether the EWM are helpful
Community involvement in flood management	Action taken by community - flood warning
	Community involvement in EWM
	Community training
	Community willingness to take preventive measures
	Duration of stay in evacuation areas
	Evacuation during floods
	Help/aid received during floods
	Number of evacuation centres
	Use of warning messages
Disaster response capacity of county government	Budget allocation
	Department responsible for forecasting
	Disaster/emergency preparedness plan
	Information sharing and coordination
	Partnerships
	Role of County government <i>and</i> department

Marginalized, vulnerable groups and gender integration	Consideration of marginalized/vulnerable groups
	Effect of floods on gender
	Gender integration
	Inclusion of GBV

4. Results and Findings

4.1. Remote Sensing and GIS Results

GIS was used to generate flood maps from 2008 to 2024 (figure 1). The flooded areas show that there are two distinct areas that experience flooding, the southwest (SW) of the study area, the central region, and the northeast (NE) of the study areas. The one to the southwest is along the Lake Victoria shoreline while the other two locations are floods that occur along the rivers.

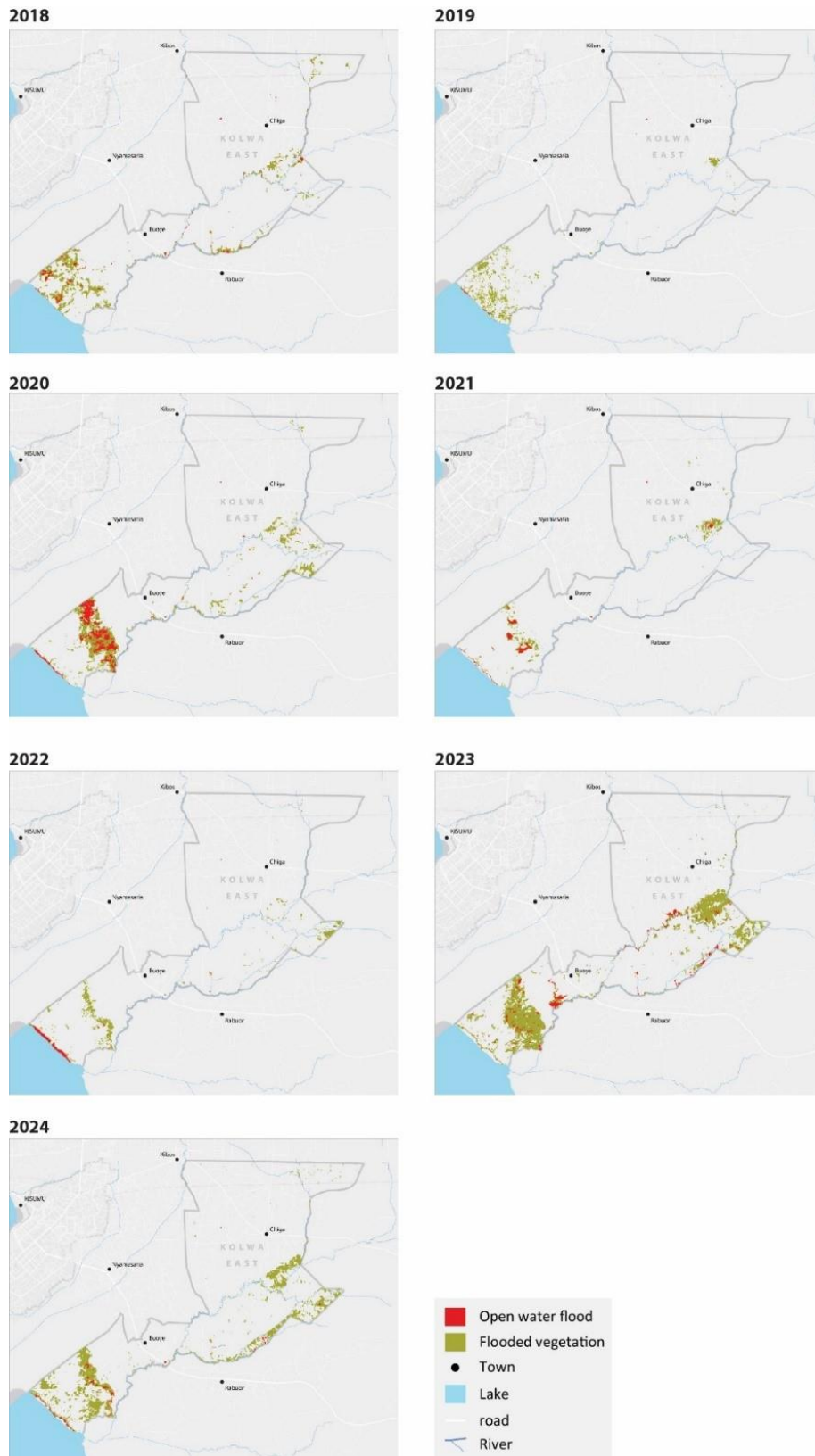


Figure 2: Flooded covered region during the March-April-May Seasons between 2018 – 2024

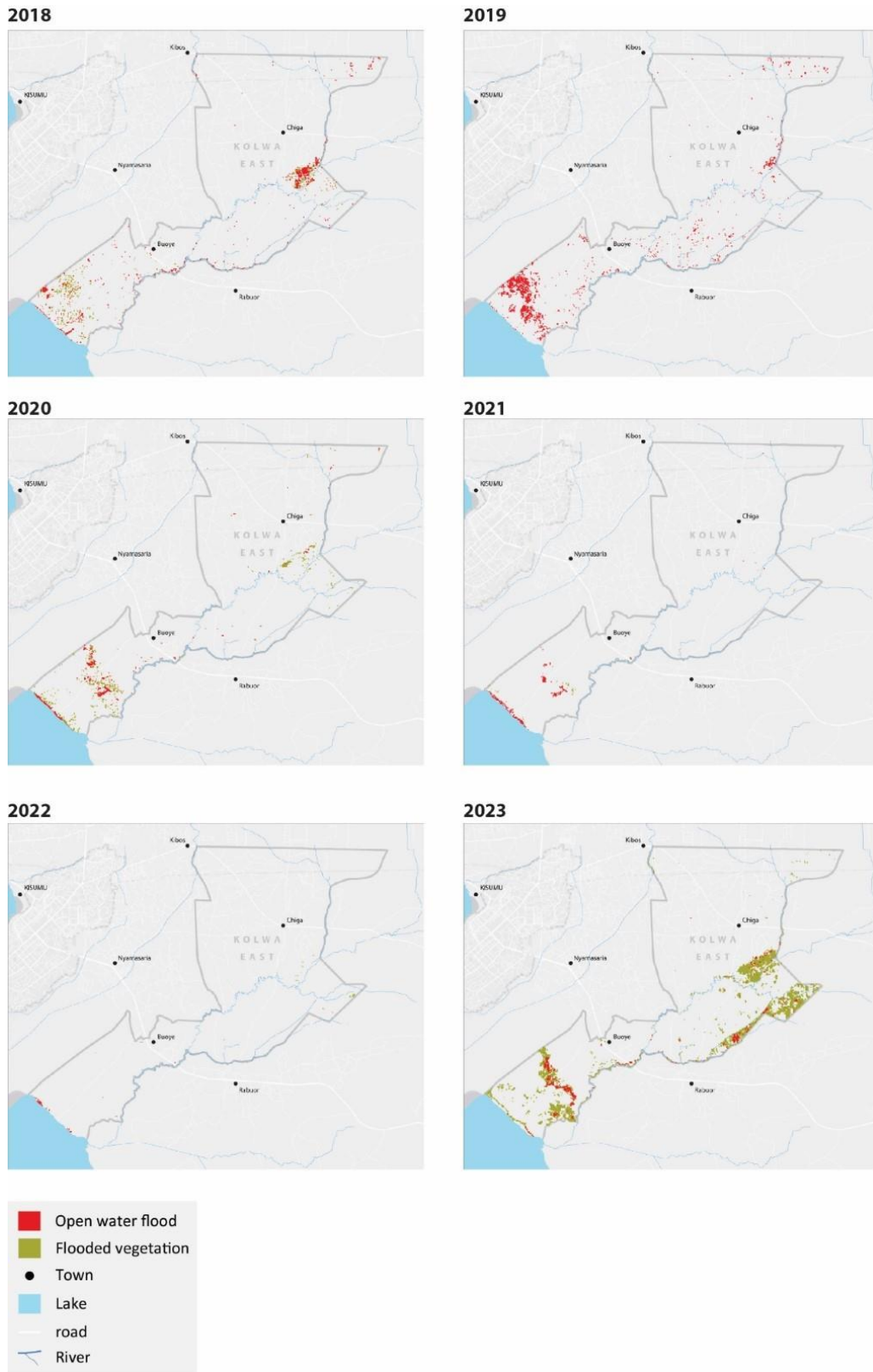


Figure 3: Flooded covered region during the October-November-December Seasons between 2018 – 2023

The results on surface area of floods between 2018 and 2024, shows that the year 2023 experience the highest flooding with the bulk areas of 631 Ha flooded in the March-April-May (MAM) season while the October-November-December (OND) area flooded was 433 Ha. These are between 2 to 3 orders of magnitude for the other years in the study period. In general, the surface area under floods in the MAM season is greater than the OND season.

Table 4: Surface area in Ha flooded during the MAM and OND seasons 2018-2024

Year	Season				TOTAL	
	March-April-May (MAM)		October-November-December (OND)		MAM	OND
	Flood	Flooded vegetation	Flood	Flooded vegetation		
2018	35	230	83	54	265	137
2019	10	127	152	0	137	152
2020	116	268	45	62	384	107
2021	25	84	28	5	109	33
2022	32	103	6	4.00	135	10
2023	64	567	58	375	631	433
2024	23	290	N/A	N/A	313	N/A

4.2. Results from the Qualitative Analysis

Theme 1: Knowledge of the Climate Risk

Causes, Duration and Frequency of Floods

The majority of the respondents were knowledgeable about the climate risks they face and explained the causes. The participants were able to draw a connection between weather occurrences and the subsequent hazards they faced. The causes of floods were identified as heavy rainfall, poor drainage systems, poor waste disposal systems, encroachment into the riparian zones, decrease in tree cover, and siltation of rivers. Participants observed that the frequency of floods varies but has generally been increasing and more unpredictable in the recent times. The duration of floods also varies

depending on the duration and magnitude of rainfall. These positions are illustrated by the following quotes.

Quote	Source
<p>“In Kolwa East, flooding occurs due to the backflow of water as a result of heavy rains in the highland. Poor drainage in the area also contributes to the impact of the flood. Poor waste disposal systems cause clogging of drainage channels therefore causing flooding. Kolwa East has low tree coverage due to cutting down of trees and this causes soil erosion. Rivers in the area are shallow due to siltation; desiltation should be an annual activity.”</p>	<p>FGD 3_Mixed</p>
<p>“Floods are experienced majorly during the months of March, April, May and October, November, December. Sometimes flooding occurs twice or thrice a year depending on the intensity of the rain season. In the past, floods occurred once a year but floods have become unpredictable since 2020. In December 2023, it rained once but heavily resulting in flash floods. In the last 10 years flooding has been experienced every year.”</p>	<p>FGD 3_Mixed</p>
<p>“In Kolwa East floods occur due to backflow from the rivers and from the rains. Floods from backflow sometimes take up to 3months to dry up.”</p>	<p>FGD 3_Mixed</p>

Theme 2: Climate Change Effects

Effects of climate change on the community

Most of the stakeholders mentioned that they were aware of climate change phenomenon. Climate change was manifested through change in temperature and weather patterns. Stakeholders expressed several views on their perception about the effects of climate change, but mainly converging on the following: 1) displacement, 2) shift in planting seasons, 3) increase in drought and flood frequency, 4) heavy and unpredictable rainfall, 5) food insecurity, 6) health issues, 7) disruption of livelihoods, 8) separation of family, 9) stress and mental health, 10) Gender-based violence, 11) cultural disruption 12) destruction to their houses. This is illustrated by the following quotes.

Quote	Source
“Climate change is a periodic and regular occurrence in weather patterns that extends for a period of time (years).”	KII_8_NEMA
“Climate change has adversely affected the community. The rains have become unpredictable and flooding more prone. It has changed normal practices such as farming and other livelihood activities like fishing and pastoralism. General practices of the community including cultural practices have been affected.”	KII_5_Subcounty administrator
“Climate change has affected farming because rains have become unpredictable unlike in the past. Climate change has caused displacement of households due to floods. Land has been inundated and families forced to move from their homesteads. Climate change has also caused food insecurity since crops are destroyed”.	FGD 1_Males

Theme 3: Early Warning Awareness

The respondents indicated that they are aware of EWM and that they received the EWM mainly from Kenya Agricultural and Livestock Research Organization (KALRO) KMD, and Red Cross via SMS, radio and television. A few mentioned receiving EWM from the Digifarm App and ishamba app.

Quote	Source
“Yes, these are the messages we receive through SMS or hear on radio and tv warning about onset of heavy rains”	FGD_3_Mixed
“We received SMS from Red Cross warning us that it will rain above normal and people should move to higher ground”.	FGD_4_Mixed

The stakeholders further mentioned that KMD early in 2024 sent out several advisory warnings regarding the onset of heavy rains in several parts of the country including

Kisumu County. However, there was minimal early action by the national or county governments to prepare the nation or community for the impending flood or sensitize them on how to mitigate the effects of flooding. Residents in affected areas were however advised in the early warning messages to move to higher grounds, without facilitation or proper direction on where to move. In the most recent flooding, which occurred between April to May 2024, lives and livelihoods were lost and property destroyed; the floods were caused by a backflow from Lake Victoria due to its rising water levels and spewing into different areas including Kolwa Eastward.

Communication and dissemination of EW messages

Participants expressed mixed reactions regarding access by County government of Kisumu to timely weather forecasting information. Some expressed that the weather information is not received while others were of the view that the information is usually relayed. The disparity in information could be due to that reason that the dissemination channel used didn't reach all the community members who received EWM through radio, television, SMS or chief's barazas as opposed to the government stakeholders who receive EWM through emails, memos and departmental WhatsApp groups. Still those who mentioned that the county had access to sufficient information noted that there are resource constraints hence affecting disaster preparedness action. Therefore, the need for partnership between County Government of Kisumu and other private partners to help in the dissemination of EWM.

Quote	Source
"The County government does not have access to timely weather information; if it did it wouldn't use the reactionary approach to disaster management."	KII_9_Deputy Director Early Childhood Department
"Not adequately, WRA does pegging on a need basis. In some areas the water markers are not known since pegging wasn't done thus there is inadequate information on the rise or fall in water levels."	KII_8_NEMA
"The county government has access to sufficient information but lacks adequate resources for preparing and disseminating the	KII_6_Youth Gender and PWD advisor

weather forecasts. More partners needed to help the government in forecasting and dissemination.”	
“EWM only reaches the farmers who had registered for the Kenya Climate Smart Agriculture Program (KCSAP). I have been receiving SMS from KCSAP for the last 3 years. Visually impaired persons have to rely on family or friends to read to them their SMS received in the evening after work; therefore, they are not able to react to urgent EWM”.	FGD_1_Males

Accuracy, Timing, Language, Specificity, and Content of early warning information

Participants generally mentioned inaccuracies in the early warning messages. However, they noted that there have been improvements in the accuracy of warnings in the recent years. Generally, stakeholders noted that the early warning messages were relayed before and during the disaster. However, it was mentioned that the messages do not indicate when to take action and the exact time the floods will occur. Also, information about the magnitude of the floods is not provided. The early warning information is mainly received in English and Kiswahili languages, although some local radio stations broadcast in the local dialect (*dholuo*). Participants also noted that the information is usually specific to the county, but not cascaded to the ward level. EW messages don't indicate the specific time for the occurrence of floods and the higher ground/alternative place to move to

Quote	Source
“The EW messages have been inaccurate in the past. Weather forecast on application is mostly 95% accurate. In the past, the weather forecasts from the Kenya meteorological department are sometimes inaccurate and unreliable. In the last two years the forecast from KMD has been accurate. EW messages from KALRO were accurate and reliable”	FGD 1_Males
“Early warning messages are broadcasted before and during the disaster. Messages are broadcasted on television in English and the native language, vernacular radio stations and village barazas also broadcast early warning messages.”	KII_13_Special Programs - Disaster Management

<p>“Information received from the Early warning messages do not indicate when floods will occur or if they will occur in the area. The messages however forecast the onset of the rains and alert on possibility of floods. The extent of flooding or when it will flood is not indicated”</p>	<p>FGD_3_Mixed</p>
<p>“Yes, the early warning messages were specific to Kisumu County but doesn’t give forecast specific to Kolwa Eastward.”</p>	<p>FGD 2_Females</p>

The participants indicated that the messages were helpful to the farmers since they got advice on farming, the climate smart agricultural practices to adopt during the flooding season and from the alerts, they are aware that rains are coming. A participant mentioned that he advises farmers on when to put up tree nurseries or implement smart farming practices based on EWM.

Most of the respondents felt that the EWM were generic and not so helpful because it advised them to move to higher ground yet due to the nature of terrain in Kolwa, there is no higher ground to move to. Secondly evacuation centres are inadequate, so the messages don’t advise them, where to move to.

Quote	Source
<p>The messages we receive tell us to move to higher ground. Where is this higher ground or even an alternative place to move to like evacuation centres? We are forced to stay in our flooded homes because we don’t have an alternative safe place to move to. Sometimes some villagers whose homes are not flooded will offer to accommodate some of the affected households until the flood waters recede.</p>	<p>FGD 4_Mixed</p>

Mixed reactions were reported regarding the respondents’ understanding of the early warning messages. Some community members understood the messaging while others, mainly the elderly, the illiterate and those with disability needed help to understand the early warning messages. They recommended that the community be involved in designing and dissemination of the EW messages to ensure that special groups’ interests are considered.

Quote	Source
I have done research to find out how much it will cost to have a voice app installed in my phone. This app will help me with reading messages received on my phone since I am visually impaired. Currently I am forced to rely on a family member to read to me all the messages I have received in a day in the evening. This means that if an EWM had been sent earlier informing me to take rapid action, I would be unable to	FGD 1_Male

Indigenous Knowledge (IK)

Participants observed that the community possesses indigenous knowledge in early warning by using observation such as patterns in wind movement, birds' migration patterns, animal cries, behaviour of certain plants and trees. The IK is mainly used in prediction of weather events mostly rainfall. However, with climate change, it was observed that IK is increasingly becoming inaccurate due to unpredictability of weather events owing to their erratic nature. In addition, participants noted that IK does not provide specific prediction of weather events such as the intensity and amount of rainfall. Most participants also noted that IK is not considered by either the KMD or other government agencies in preparation of early warning messages.

Quote	Source
“There is no IK that shows approaching floods. The community is often caught unawares in case of flooding. IK like birds migrating or the direction of the birds' flight signify approaching rains. The <i>Albizia cori</i> (Ober) plant flower pattern indicated rains were approaching. Flowering pattern of the mango tree indicate flood/drought. This knowledge is used to forecast rains but not for floods; backflows are especially hard to forecast since they normally occur at night unexpectedly.”	FGD 1_Males
“Indigenous knowledge is not yet incorporated. There is a gap in mainstreaming this information in early warning messages e.g. birds' migration patterns, animal cries, wind movement patterns, plants.”	KII_13_Special Programs – Disaster Management

<p>“Indigenous knowledge is known but not adequately utilized. The community relies on early warning messages received more than indigenous knowledge. This is because indigenous knowledge doesn’t show how much rain is expected.”</p>	<p>KII_3_Community Health Promoter</p>
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Theme 4: Community Involvement in Flood Management

Participants expressed that there were no gazetted evacuation centres in the ward prompting flood victims to seek refuge in nearby public facilities such as schools and churches which have been designated as evacuation centres. This was seen to be a challenge given that schools cannot be used as evacuation centres when learners are in session; however, when used during school session, learning is disrupted because the flood victims stay in evacuation centres until the floods recede. Aid is normally provided to the flood victims in form of food items and non-food items for example beddings by NGOs, and county and national government. The participants mentioned that the aid is usually little and given disproportionately; the affected families in need of help don’t get the aid due to corruption and a not so well-planned distribution prioritization criterion. The flood victims stay in evacuation centres until the floods recede.

Community members expressed that they were willing to take initiatives towards disaster preparedness. The community mentioned the food for work program was a very successful initiative whereby the community provided labour to clear dig and clear drainages ahead of floods and in return got food; however, the program came to an end. These days preparation for the floods is done on an individual basis. Nevertheless, some community members have adopted a wait and see approach and are usually unwilling to move to safer zones until when floods occur.

Cultural factors and gender roles also discourage them from moving away from their homes. For instance, men remained behind to guard the household goods and assets from thieves who take advantage of floods to steal from households where the members have evacuated to seek refuge elsewhere. In addition, men are uncomfortable moving to the evacuation centres due to fear of meeting their mother-in-law. In Luo culture, men shouldn’t sleep under the same roof as their mother-in-law. Also, daughters and fathers shouldn’t sleep in the same room; due to the limited space in the evacuation centres, men prefer to stay in their flooded homes due to these factors but evacuate their families to any available evacuation centres.

Quote	Source
<p>“There is no evacuation centre in the ward, so people move to identified schools or churches (for example Nyaimbo, Rweya and Rongo primary schools) until the floods recede. However, during school days, the affected villagers are housed by willing villagers not affected by the floods. Currently about 50 households are still living outside their homesteads due to floods. They are being housed by others in the community since there is no evacuation centre in the area”</p>	<p>FGD 3_Mixed</p>
<p>“Sometimes from the government and NGOs. Affected persons usually cater for their own needs while in the evacuation Centre. Help is usually unreliable since its random and insufficient. Corrupt officials tasked with registration of affected persons sometimes give priority to their friends and family who might not be affected by the floods and fail to help those that actually need it.”</p>	<p>FGD 3_Mixed</p>
<p>We are willing to take initiative as the affected community towards flood preparedness but lack the capacity. The County government should consider reviving the food for work program. The community provided labour for opening drainages and digging trenches before occurrence of floods and in turn they got food. Now we have to go out to search for work so that we can earn a living and be able to purchase food; this leaves us with little time to open drainages; this has now become an individual effort</p>	<p>FGD 4_Mixed</p>

Community Participation in Design of Early Warning Systems

Generally, participants observed that the community is not involved in the designing of early warning systems. Most participants were not aware of the existence of a disaster management committee in the county. It was noted that public participation is not usually carried out prior to formation of these committees and during their operation. It emerged that the County government relied on the existing climate change structures to

disseminate EWM. Before the formation of the climate change committee structures, extensive stakeholder participation was done. The climate change structures are well defined starting from the top at the county government level to the bottom at village level where community representatives have been appointed to represent the larger committee. Based on this, the government stakeholders indicated that a disaster management committee had been formed and community was involved yet the community hadn't been involved. In addition, the mandate of the climate change committee and disaster management committee are totally different. The local administration however pointed out that the community was part of the disaster management committee. Participants also observed that no training on disaster preparedness had been offered to the community members.

Quote	Source
<p>“The community doesn’t have any training so they rely on indigenous knowledge to forecast and prepare for floods by taking measures such as moving cows to higher grounds, raising household stuff, moving household assets to friends and relatives’ houses who have not been affected by the floods for safe keeping.”</p>	<p>KII_4_Area Sub Chief</p>
<p>“Early warning messages warn them to move to higher ground but due to challenges the flood victims don’t move until the floods occur. Some may have alternative options but majority of the community do not move due to attachment or they are afraid thieves will strike when they vacate their homesteads. Sometimes alerts are not accurate so the community don’t move. Cultural beliefs e.g. father and daughter can’t sleep in the same hall or in-laws can’t sleep under one roof hinder some flood victims from moving.”</p>	<p>KII_13_Special Programs – Disaster Management</p>

Theme 5: Disaster response capacity of County Government

Disaster and emergency preparedness plan

Stakeholders expressed varying views on the existence and operationalization of a disaster and emergency preparedness plan. Stakeholders mostly from the county government pointed to the existence of a disaster and emergency preparedness plan

while those from non-governmental organizations, civil society and the private sector were not aware of such a plan at the county level. The county government relies on the existing climate change committee structures to disseminate early warning messages thus the divergent point of views. An *ad hoc* committee comprising of both state and non-state actors is quickly constituted whenever flooding disasters occur. The following quotes illustrate these positions.

Quote	Source
“There is no plan in place. The county relies on the existing climate change committee structures to respond to disasters. Disaster committee has been set up but not fully functional”	KII_6_Youth Gender and PWD Advisor
“Yeah, we have a disaster plan, though its domains are majorly in the Department of Special Program. We have a plan under the Department of Special Program, though we work as a committee. During the disaster, we form a disaster committee. There was a time the committee developed a work plan to develop a disaster mitigation plan.”	KII_11_Department of Road, Transport and Public Works

Information sharing and coordination

Some respondents mentioned that dissemination of early warning information is done through a multisectoral approach involving various stakeholders from the county government departments e.g. department of water, health, roads, early education, and non-state actors e.g. Red Cross However, those from local administration noted a disconnect in early warning information sharing. They expressed that the local administration is not involved or alerted. The office of the local chief is under the jurisdiction of the national government; however, the chief doesn’t get early warning messages on time. This was possibly due to the channel in which the information is coordinated and disseminated. KMD disseminates the information through emails and bulletins to the county government starting from the governor’s office, the information is then cascaded down to the other county departments, then subcounty level, ward level and finally the village level. These views are captured in the following quotes.

Quote	Source
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<p>“The county government of Kisumu have structures that start from the governor, then at the sub-county levels, we have the sub-county administrator. Then at the ward level, we have the ward administrator. At the village level, we have the village administrator. Each ward has two villages. Now, once the committee has made a resolution on some of the issues that they are to handle during disaster management, they will communicate this through that channel of the local administration, the sub-county, to the ward administrator, to the village administrator, which also is going to communicate to the community and feedback from them is gotten.”</p>	<p>KII_11_Department of Road, Transport and Public Works</p>
<p>“No information is sent to the chief to alert people; rather the community has organized themselves through their social structures to ensure that all the community members know about the forecasted floods.”</p>	<p>KII_4_Area sub-Chief</p>
<p>“There is a disconnect here; the village elders are under the national government. However, village administrators who are under the jurisdiction of the county government don’t share the information with the elders.”</p>	<p>KII_5_Village elder</p>

Further, some respondents reported that there exists some level of partnerships between the county government and other stakeholders in relaying and disseminating early warning information. However, some noted that partnerships were not working well because of resource constraints. This is illustrated by the following quotes.

Quote	Source
<p>“County government has partnered with organizations such as the Red Cross in sending out early warning messages through SMS. The county government has partnered with local non-governmental organizations for example in Kolwa Eastward the county government has in the past partnered with ‘make me smile’ to provide basic essentials to flood victims in the area. The county government has also partnered with radio stations to air early warning messages.”</p>	<p>KII_3_Community health promoter</p>

<p>“Through coproduction and codesign of forecasts though it is not done frequently due to limited resources. Sometimes the end users of climate information services are engaged to establish their understanding of early warning, needs and expected outcomes.”</p>	<p>KII_7_Kenya Meteorological Department</p>
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Role of government and Departments

Stakeholders noted that the national and county governments play various roles in early warning and preparedness. The roles of county government were mainly seen by the community, county government officers and non-governmental officers to be sensitisation, mobilizing stakeholders to give donations for flood victims, budgeting for mitigation activities and formulation and enforcement of policy and legal framework. Although some participants noted that there is no budget allocation for early warning and preparedness. The national government was mainly seen to play a role in early warning, provision of aid, and resource mobilisation. Representatives from county government and local administration stated the following.

Quote	Source
<p>“Yeah, the county government of Kisumu has various roles in regard to disaster preparedness and how to mitigate certain disasters that may arise. One, as a government, we do sensitization in regard to maybe a disaster that we are foreseeing might occur; the sensitization is majorly done in the Kano plains. The community is sensitized on how to keep safe during floods and when to move to higher grounds”</p>	<p>KII_11_Department of Road, Transport and Public Works</p>
<p>“Giving warnings to the community about impending floods, sourcing for relief items that will be given to the affected communities, desiltation of rivers. Setting up evacuation centres, ensuring availability of adequate sanitation facilities and organizing medical camps, resource mobilization for disaster preparedness, setting up designated drainages/clearing drainages, desilting rivers, before rains to help control floods.”</p>	<p>KII_5_Village elder</p>

<p>“There is no budget allocation. No, that is where we have a challenge. If you look at our County Integrated Development Plan (CIDP), the third generation CIDP, it is clearly in that physical document. But I think because of the budget ceilings, usually items are knocked out. And it has never been given prominence in the actual budget. So, it is there in the CIDP, but it is never cascaded into the budget allocations.”</p>	<p>KII_13_Special Programs - Disaster Management</p>
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In addition, several departments at the county and national level were perceived to be playing a key role in early warning. The county departments include the departments of water, health, environment and climate change, roads and agriculture. At the national level, the KMD and the WRA were identified as a key department in early warning. The quotes below demonstrate these positions.

Quote	Source
<p>“The roads department is concerned with desilting rivers before floods occur, the health department is concerned with ensuring they have adequate water guards for disinfecting water wells, county government mobilizes for funds and allocates resources, Red Cross and other NGOs are involved in emergency response (first responders)”</p>	<p>KII_2_Red Cross Officer</p>
<p>“The Kenya meteorological department is responsible for forecasting and sending out the early warning messages. Information is shared via email messages and sent to all departments. As soon as it is received by Climate Change Directorate it’s shared out.”</p>	<p>KII_14_Climate information Services</p>
<p>“There are three departments in WRA that are responsible for forecasting; hydrology department which monitors the state and water volume of the rivers, lakes and streams, community development department which is a link between the community and WRA and conservation department whose mandate includes ensuring safety of the community from flooding of water bodies”</p>	<p>KII_10_Water Resources Authority</p>

Theme 6 Consideration of Marginalized, Vulnerable Groups and Gender Integration

Participants observed that vulnerable groups such as those living with disability and the illiterate do not benefit from early warning messages because the messages are not customized for them. There has not been a deliberate plan to translate the messages to sign language or braille.

Quote	Source
“These messages are not accessible by some community members e.g. the visually impaired, illiterate, the elderly. Sometimes the messages are broadcasted when women are busy with their household chores thus missing this information.”	FGD 4_Mixed
“The blind receive the SMS but have to rely on their family members or trusted neighbour to read for them. The illiterate is unable to read their SMS messages.”	FGD_3_Mixed
“Flood victims under prescription drugs (HIV/AIDS) are afraid of taking their medication while living in the camps due to fear of stigma. Sometimes their medicine is washed away by flood waters causing them to default on their medication routine”	FGD_2_Female

Gender Dimensions

Participants observed that both men and women are vulnerable during periods of floods due to disruption in their normal activities. Both men and women were equally affected by floods. The men indicated that during floods they are forced to stay in their flooded homes to guard their assets while women and children move to evacuation camps. Some stakeholders also noted a likelihood of increase in gender-based violence during floods due to stress from loss of income and assets. Women on the other hand indicated that they had to worry about where to light a fire during floods to prepare a meal for their families, women are forced to trade in sexual favours in exchange of food (fish) or water given that women have to travel a long distance in search of water. In addition, the community mentioned that widows are very vulnerable because they do not have help

from a spouse and have to oversee both the flooded evacuated home while caring for their children at the evacuation centre.

Quote	Source
<p>“Women are more affected than men, when families are displaced by floods, families living in higher grounds may take in various displaced families, women are in charge of organizing and allocating spaces and there might be overcrowding from having several families in one household, which does not allow for privacy or freedom in preparing meals. Some women might have their livestock and farms destroyed by the floods therefore exposing them to poverty.”</p>	<p>FGD 4_Mixed</p>
<p>“Men are also impacted by floods since they have to provide for their families. When the main source of livelihood is lost (farms) depression cases increase. Men find it hard to speak out their challenges or share with their friends, so they end up bottling up their problems leading to stress and depression. This anger and frustration are taken out on their wives. Depression can cause gender-based violence in such homes.</p> <p>Men are forced to find alternative sources of income for example to find casual jobs which are scarce during flooding. There are limited casual jobs during flooding so finding one is quite a challenge.”</p>	<p>FGD_3_Mixed</p>
<p>“When floods occur, the women, children and elderly move to evacuation sites while men are left in the homestead to guard the house. Families and couples become separated causing anxiety and lack of conjugal rights.”</p>	<p>FGD_3_Mixed</p>
<p>“Increased incidences of gender-based violence. There is a lot of frustration due to the difficult living conditions, loss of assets and loss of livelihood which increases conflict between couples”</p>	<p>FGD_1_Mixed</p>

<p>During floods men become big babies, they will go out purporting to look for work and comeback home empty handed. When they come back, they ask “<i>min ngáne itedo angó?</i>” Meaning mother to so and so what have you cooked? Women are forced to be the providers for their families. After feeding the children and taking them to sleep, the women are still engaged with chores such as washing dishes. The man comes demanding for sex and if the woman says she is tired or still busy she is either beaten or the husband forcefully has sex with her. There are increased cases of rape in marriage during floods</p>	<p>FGD_2_Women</p>
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5. Discussion and Implications

Our findings indicate that despite the importance of an EWS, there is still inadequate coverage in Kolwa Eastward. An EWS can only be effective when it is accessible by the intended recipient. This study established that despite floods being experienced perennially in Kolwa East, there is a deficient EWS system in place which leaves the last mile community more susceptible and vulnerable to flooding effects.

Knowledge of the climate risk

The findings of this study indicate that the stakeholders were knowledgeable about the climate risk that faces them that is flooding. It is important for the community to have an understanding of the relationship between climate risk and climate change as this will influence their actions towards addressing climate change and reducing their vulnerability. The community in Kolwa East demonstrated they had knowledge on floods. It is vital for community members to possess knowledge on climate change to enable them understand the actions they can take to either lessen or prevent climate change impacts. (UNDP, 2016b).

Climate change effects

Climate change continues to wreak havoc and its effects are clearly evident. The finding of the study is in tandem with Masese et al. (2016) floods have become one of the most destructive environmental disasters affecting the lower Nyando Basin in Kisumu County, Kenya. They have severe impacts on people's environmental, psychological, physical, economic and social well-being. Floods result in physical and psychological health (Speis et al., 2019). The respondents indicated that they start feeling anxious and stressed whenever it starts raining because rains are associated with floods which result in the loss of their assets, household goods, destruction of houses, loss of economic activities and disruption in their way of life. The floods also destroy all the infrastructure leaving the affected community marooned and unable to access vital services like health care.

Flooding leads to fatalities, mental health challenges, financial setbacks, and damage to infrastructure. It also exacerbates a community's economic status due to destruction of their livelihood activities (Odero and Mahiri, 2022; Glago, 2021)

Early Warning awareness

According to UNDP (2016b) inadequate knowledge among community members causes a disconnect between what is occurring globally and nationally and how community activities, individual activities, countrywide activities and worldwide actions contribute to emissions of greenhouse gases and the resultant climate change that is being experienced.

Our findings indicate that the respondents were aware about EWS and its functions. However, it emerged that the existing EWS was fragmented. Some received EWM from Redcross, KALRO, KMD and Digifarm App. The various different platforms between government and other agencies are an indication of insufficient coordination between government ministries and other agencies when it comes to implementation of EWS for various different hazards (Lumbroso, 2018). Further despite the awareness of EW messages, they were not customised to the Kolwa community which deterred the community from responding to these messages. The EWM indicated that the residents should move to a higher ground. This area is a flat terrain thus no alternative higher ground to move to.

Communication and dissemination of EW messages

Access to timely weather information and dissemination of the EW message in a language clearly understood by the recipients is vital to the success of an EWS. For

effective risk communication, it is essential that warning information is distributed promptly and presented in clear, easily understandable language. To achieve this, capacity building at various levels may be necessary, as highlighted by UNEP (2012). EWS must be customised to fit the specific needs of the community (Baudoin and Wolde-Georgis, 2015).

The dissemination of accurate and timely EWM is crucial for effective disaster preparedness and response. Based on the insights shared by participants, it is evident that the County Government of Kisumu faces challenges in accessing and communicating weather forecasting information to its residents. While some participants acknowledged receiving EWM, others expressed concerns about the lack of access to timely information. This discrepancy highlights the need for a more robust and coordinated system for collecting, analysing, and disseminating weather data and forecasts. Collaboration between government agencies, meteorological departments, and local communities could help bridge this gap and ensure that critical information reaches those who need it most.

Participants also raised concerns about the accuracy and specificity of EWM. While improvements have been noted in recent years, there is still room for enhancing the precision and localization of these warnings. Providing detailed information about the timing, magnitude, and location of potential floods could empower communities to take appropriate preparedness measures. Furthermore, the language and content of EWM should be tailored to the local context. While English and Kiswahili are commonly used, incorporating local dialects like Dholuo could improve understanding and reach a broader audience. Additionally, the messages should provide clear guidance on specific actions to take, such as identifying safe evacuation routes and designated shelters.

Community involvement in flood management

Developing countries are faced with the challenge of inadequate resources for establishment and maintenance of FEWS (Díaz *et al.*, 2014a). These includes establishment and maintenance of hydrometeorological observation networks (rain and river gauge stations), data assimilation systems and computer processing capacity (Moisès and Kunguma, 2023; Perera, Agnihotri, *et al.*, 2020). Inadequate funding for system maintenance may result in discontinuation of system operations (Moisès and Kunguma, 2023). Collection of data from gauge stations normally stops because of failure to maintain such systems following the stoppage of projects which are foreign funded (Almoradie *et al.*, 2020). Despite the county government of Kisumu allocating 2%

of its budget to climate actions, this is not adequate to fund all the climate activities in the County.

Our findings indicate that the community hasn't received any training on disaster preparedness and action despite living in a flood prone area. Further the community indicated inaction on moving despite receiving the EW messages due to lack of evacuation centres, absence of higher grounds and fear that their household goods and asset would be stolen. Insufficient local level preparedness for a response is central to the failure of FEWS. Lack of evacuation centres and routes (Dutta and Basnayake, 2018); irregular and limited simulations and drills (Dutta and Basnayake, 2018; Perera, Seidou, *et al.*, 2020) are among the causes of failure of FEWS. These findings reveal that the County Government of Kisumu has inadequate disaster response capacity hence the reason for the inadequate implementation of EWS in Kolwa East.

The discussion around community participation in disaster management and response highlights some critical gaps that need to be addressed. While the local administration claims that the community is part of the disaster management committee, the community members themselves seem unaware of such committees or any opportunities for public participation. This divergent view points to the perception that EWS are primarily meant to address the needs of the government or other organizations that operate at either the national or regional level (Lumbroso, 2018). This may explain why the government stakeholders who participated in the KII mentioned the existence of a disaster committee. This disconnect is concerning as it undermines the effectiveness of disaster preparedness and response efforts. Effective disaster management requires a collaborative approach, where the community is not just a passive recipient but an active participant in the process. Community involvement ensures that local knowledge, needs, and priorities are taken into account, leading to more contextualized and sustainable solutions. Without community participation, disaster management plans and strategies run the risk of being disconnected from the realities on the ground. A study by Sufri *et al.* (2020) revealed that community engagement is vital to limiting environmental damage linked to disaster occurrence, reducing injuries and saving lives. Collaboration with the local community is necessary so as to reach the last mile (UNDRR and WMO, 2024).

Furthermore, the discussion revealed the existence of indigenous knowledge regarding weather patterns and natural indicators. While this knowledge is primarily used for anticipating rainfall, it does not provide specific predictions for floods or their intensity. Integrating indigenous knowledge with scientific forecasting could enhance the community's preparedness and resilience. By bridging traditional wisdom and modern technology, early warning systems could become more comprehensive and culturally relevant. According to (Díaz *et al.*, 2014b; IFRC, 2009) integrating scientific knowledge

with local insights is crucial for delivering accurate and dependable monitoring and forecasts, ensuring valuable information is provided to authorities, relevant stakeholders, at-risk communities, and the general public.

Furthermore, the lack of training and capacity building for community members is a significant barrier to their meaningful engagement. Indigenous knowledge alone may not be sufficient to navigate the complexities of modern disaster scenarios. Equipping community members with relevant skills and knowledge through training programs can empower them to take proactive measures and contribute effectively to disaster preparedness and response efforts. According to (Chou *et al.*, 2015; Ersoy and Koçak, 2016) education, training, preparedness and risk awareness programs for all disaster management actors including communities play a vital part in improving response capability. Inadequate community training and involvement in Kolwa East poses a significant problem for disaster response. Various studies have established the importance of engagement of the community in EWS to ensure the effectiveness of the design and operation of the system (Andreastuti *et al.*, 2019; Baudoin *et al.*, 2016; Cools and Demetrio Innocenti, 2015).

Additionally, the community's willingness to take initiatives towards disaster preparedness is encouraging. Initiatives like the food-for-work program have proven successful and could be expanded or replicated. However, cultural factors and gender roles that discourage relocation during floods must be addressed sensitively, fostering an environment where all community members feel empowered to prioritize their safety.

Disaster Response Capacity of County Government

Another critical aspect highlighted by participants is the lack of resources and support for disaster preparedness efforts. The County Government may have access to information but face constraints in effectively disseminating and acting upon it. Fostering partnerships with non-governmental organizations, community groups, and other stakeholders could help mobilize resources and enhance the county's capacity for disaster risk reduction. This finding is in line with findings by various authors who established that inadequate funds is a major challenge faced by developing nations in reference to maintenance of FEWS (Aguirre *et al.*, 2018; Almoradie *et al.*, 2020; Moisés and Kunguma, 2023; Perera, Agnihotri, *et al.*, 2020; Perera *et al.*, 2019; Perera, Seidou, *et al.*, 2020). Addressing these challenges requires a multi-faceted approach that involves improving data collection and analysis, enhancing communication channels, tailoring messages to local contexts, and strengthening resource allocation for disaster preparedness. According to Lumbroso (2018), in many Sub-Saharan African countries

there is insufficient budgeting for EWS despite the immense benefits that can be realised from these systems. In Africa, only three countries were considered to have an effective FEWS in minimising impacts to people that is Djibouti, South Africa and Cameroon; the EWS in seven other countries (Kenya, Tanzania, Egypt, Mozambique, Ghana, Madagascar and Malawi) was deemed moderately effective (Lumbroso *et al.*, 2014). This highlights the need for governments to invest in EWS to reduce the impact on people following climate disasters occurrences.

By prioritizing these areas, the County Government of Kisumu can better protect its residents and build resilience against the impacts of floods and other natural disasters. Kisumu county government has allocated 2% of its county budget to climate actions but this is still inadequate; this calls for enhanced partnerships with both state and non-state actors to bridge this financial deficit. Samansiri *et al.* (2023) posits that the insufficiency of available funds, along with the shortage of expert acquisition and capacity building, poses a major challenge to the effective operation of FEWS. The lack of designated evacuation centres and the uneven distribution of aid during floods also emerged as significant concerns. Establishing designated evacuation facilities and ensuring equitable aid distribution should be priorities for disaster management efforts. Involving the community in identifying suitable locations and developing fair distribution mechanisms could help address these challenges effectively.

Overall, the discussion highlights the importance of inclusive communication, integrating indigenous knowledge, establishing robust evacuation plans, ensuring equitable aid distribution, and addressing cultural barriers. By actively involving the community and considering their diverse perspectives and needs, flood management efforts can become more effective and sustainable. Dutta and Basnayake (2018) established that lack of evacuation routes and centres contributes to the failure of FEWS. Effective information sharing and coordination are also crucial aspects that require attention. The disconnect in early warning information sharing between different levels of administration and stakeholders can lead to delays, confusion, and ineffective response. A well-coordinated and inclusive communication system that involves all relevant stakeholders, including the local community, is essential for timely and appropriate action during emergencies. This finding is in line with findings by (Bhutta *et al.*, 2022; Hanchey *et al.*, 2021; Thieken *et al.*, 2023) that stresses on the need of coordination between all the actors to avert failure of the FEWS. Further The absence of up-to-date and archived data for risk analysis, forecasting, and generation of early warning significantly hampers the warning and response processes (Moisès and Kunguma, 2023).

Thus, it is imperative for the county government and relevant authorities to prioritize community participation and capacity building in disaster management. This could

involve establishing transparent and inclusive mechanisms for public participation, conducting regular training programs for community members, and strengthening information sharing and coordination channels. By actively involving and empowering the community, disaster preparedness and response efforts can become more effective, sustainable, and tailored to local needs and contexts. There is also no central body that coordinates disaster preparedness and response nationally thereby limiting the response capacity of the county government of Kisumu. This finding resonates with the findings by Kiptum et al. (2023). The authors propose that governance and institutional frameworks should be rationalized by creating a national flood management coordinating body that collaborates with the National Flood Impact Assessment Centre (NFMIAC) in Water Resources Authority (WRA) to centralize flood risk data and facilitate preparedness funds, which can be activated based on forecasts. A unified disaster risk management authority, responsible for coordinating both flood and drought hazard management, may prove to be the most effective structure.

Marginalized, vulnerable groups and gender integration

Climate change poses significant challenges to communities, disrupting traditional livelihoods and practices. The increasing frequency and unpredictability of floods, droughts, and erratic rainfall patterns have far-reaching consequences for the residents of Kolwa East. One of the most pressing issues is the displacement of households due to flooding, forcing families to abandon their homes and seek shelter elsewhere. This not only disrupts their daily routines but also separates families, leading to emotional distress and potential gender-based violence. Moreover, the inundation of agricultural lands threatens food security, as crops are destroyed, exacerbating the risk of malnutrition and health issues. The shift in planting seasons and the uncertainty surrounding rainfall patterns have made traditional farming practices increasingly difficult to sustain. Livelihoods dependent on fishing and pastoralism have also been adversely affected, further compounding the economic challenges faced by the community.

Beyond the immediate impacts, climate change has broader cultural implications. Traditional practices and customs deeply rooted in the community's identity are being disrupted, leading to a sense of loss and disconnection from their heritage. While stakeholders demonstrate awareness of climate change and receive early warning messages through various channels, such as SMS, radio, television, and digital platforms like Digifarm App, the ability to effectively adapt and mitigate the impacts remains a significant challenge.

While some community members understood the early warning messages, others – particularly the elderly, illiterate, and those with disabilities – faced challenges comprehending them. This highlights the need for inclusive communication strategies that cater to diverse needs and abilities within the community. Involving the community in designing and disseminating early warning messages could be a valuable approach. By actively engaging various groups, including those with special needs, the messaging can be tailored to ensure clarity and accessibility for all. This participatory process would not only improve understanding but also foster a sense of ownership and empowerment within the community. Alfieri et al. (2014) established that disability sensitive risk communication within an efficient EWS enhances the process by providing enough lead time for survivors to develop and implement response plans before, during, and after flooding. Shelters and relief camps are often inaccessible to individuals with disabilities, making it difficult for them to access food and water distribution centres. Additionally, the lack of statistical data on people with disabilities and limited understanding of how to address their needs further increases their vulnerability during disasters or emergencies (Samant Raja and Narasimhan, 2013).

These findings are supported by findings by Perera, Agnihotri, et al. (2020) who established that exclusion of minority groups without adhering to gender equality and social inclusion (GESI) in disaster preparedness activities will result in lack of ownership, reduced interest thus resulting to decreased participation in the response. Climate change affects the different gender differently thus the marginalized gender groups are less likely to participate in EWS initiatives. In addition, due to the increased workload that women are faced with when men migrate to look for work makes it hard for them to participate (Sneddon, 2019).

6. Conclusion

A large number of the community living in Kolwa East are affected by floods annually due to the geography of the area that predisposes it to flooding. Therefore, an early warning system would be beneficial to this community to reduce losses and damages related to floods. This study aimed at examining the barriers to EWS and factors impeding comprehension and inclusivity of early warning messages on the last mile community in Kolwa East, Kisumu County. The study revealed that this community faces displacement, loss of assets, damage to infrastructure, sanitation problems, food insecurity as well as social and cultural disruption. The study established that the barriers to EWS faced by the community include: lack of evacuation centres or alternative higher

ground. Due to the unreliability of EWS received from the county government, the inhabitants also use indigenous knowledge to forecast; however, these IK can't forecast floods but only informs the community about expected rainfall. The county government doesn't have a disaster preparedness plan in place hence its reactionary response to disasters. There is also no central body that coordinates disaster preparedness and response at the national level hence the need for improvement of governance structures in flood management in Kenya.

As we grapple with the realities of climate change, it becomes crucial to explore sustainable solutions that address not only the physical impacts but also the social, economic, and cultural dimensions. Collaborative efforts involving local communities, government agencies, and relevant stakeholders are essential to develop context-specific EWS that enhance resilience and preserve the rich cultural tapestry of affected regions. By fostering a deeper understanding of the multifaceted consequences of climate change and prioritizing early warning actions that are community-focused, we can work towards creating a more sustainable and equitable EWS that will be instrumental in reducing damage and loss from floods.

6.1. Practical application for humanitarian work and recommendations

Non-governmental organizations (NGOs) are critical to the success of EWS (Omukuti *et al.*, 2021). NGOs are instrumental in offering help to the affected communities who have either been totally neglected by the government or receive inadequate support (Hailey and James, 2004). The community of Kolwa complained about lack of support from both government and non-governmental organizations. The aid offered to other communities following occurrence of drought doesn't reach them. EWSs interventions spearheaded by NGOs are very important and have boosted the readiness of the community to take preventative measures before occurrence of floods (Wagner *et al.*, 2021). This points to the importance of the NGOs involvement in EWS so as to ensure timely response from the affected community. The community in Kolwa have been forced to react to floods rather than acting towards its prevention. It is therefore evident that there is need for involvement of NGOs and humanitarian agencies in establishment of EWS given the limited response capacity of both the National and County governments to ensure timely assistance to the affected communities.

Engagement and acknowledgement of the role of NGOs in EWS is critical in ensuring the engagement of relevant stakeholders when developing a comprehensive system that will

aid the community in responding faster to flood hazards. A weak EWS forces emergency responder to react to floods rather than to its prevention thus increasing property losses and death toll. The active involvement of NGOs in flood risk reduction efforts can help bridge this information gap, as they have the potential to effectively disseminate information about flood hazards and mitigation strategies.(Shah *et al.*, 2023). It is important that both state and non-state actors are involved in the design and operationalization of a people centred EWS. In addition, NGOs have more capacity and resources to prepare and respond to disaster emergencies hence the need to involve them in disaster risk management and preparedness.

There is a need for better flood control for poorer communities that are highly at risk of recurrent flooding; this would be a crucial step in the right direction. Examples of existing low-cost solutions include better warning, floodplain zoning, building of embankments, afforestation, wetland restoration, and building embankments; implementation of these solutions will also developmental advantage given that flooding is the main cause of infrastructural damage such as clinics, hospitals, schools, roads among others in the developing countries (CRED and UNISDR, 2015). Here NGOs and humanitarian agencies will be vital in not only building the capacity of the vulnerable communities but also financing and implementing projects that will contribute to reducing the vulnerability of communities living in flood-prone areas.

References

- Aguirre, A., López, C., Osorio, A., Rivera, Toro, A., and Chang, P. (2018, June). Flood Early Warning Systems, Misconception and Challenges - The Case of Colombia. *Proceedings of the 6th International Disaster Mitigation Specialty Conference 2018, Held as Part of the Canadian Society for Civil Engineering Annual Conference 2018, Fredericton, NB, Canada, 13–16 June 2018.*
- Akinyode, B. F., and Khan, T. H. (2018). Step by step approach for qualitative data analysis. *International Journal of Built Environment and Sustainability*, 5(3). <https://doi.org/10.11113/ijbes.v5.n3.267>
- Aldardasawi, A. F. M., and Eren, B. (2021). Floods and Their Impact on the Environment. *Academic Perspective Procedia*, 4(2), 42–49. <https://doi.org/10.33793/acperpro.04.02.24>
- Alfieri, L., Pappenberger, F., and Wetterhall, F. (2014). The extreme runoff index for flood early warning in Europe. *Natural Hazards and Earth System Sciences*, 14(6), 1505–1515. <https://doi.org/10.5194/nhess-14-1505-2014>
- Almoradie, A., de Brito, M. M., Evers, M., Bossa, A., Lumor, M., Norman, C., Yacouba, Y., and Hounkpe, J. (2020). Current flood risk management practices in Ghana: Gaps and opportunities for improving resilience. *Journal of Flood Risk Management*, 13(4). <https://doi.org/10.1111/jfr3.12664>
- Andreastuti, S., Paripurno, E. T., Gunawan, H., Budianto, A., Syahbana, D., and Pallister, J. (2019). Character of community response to volcanic crises at Sinabung and Kelud volcanoes. *Journal of Volcanology and Geothermal Research*, 382, 298–310. <https://doi.org/10.1016/J.JVOLGEORES.2017.01.022>
- Attride-Stirling, J. (2001). Thematic networks: an analytic tool for qualitative research. *Qualitative Research*. <http://qrj.sagepub.com><http://qrj.sagepub.com/cgi/content/abstract/1/3/385><http://www.sagepublications.com><http://qrj.sagepub.com/cgi/alertsEmailAlerts><http://qrj.sagepub.com><http://www.sagepub.com><http://qrj.sagepub.com>
- Baudoin, M. A., Henly-Shepard, S., Fernando, N., Sitati, A., and Zommers, Z. (2016). From Top-Down to “Community-Centric” Approaches to Early Warning Systems: Exploring Pathways to Improve Disaster Risk Reduction Through Community

- Participation. *International Journal of Disaster Risk Science*, 7(2), 163–174.
<https://doi.org/10.1007/S13753-016-0085-6/TABLES/1>
- Baudoin, M. A., and Wolde-Georgis, T. (2015). Disaster Risk Reduction Efforts in the Greater Horn of Africa. *International Journal of Disaster Risk Science*, 6(1), 49–61.
<https://doi.org/10.1007/s13753-015-0041-x>
- Bergquist, M., Nilsson, A., and Wesley Schultz, P. (2019). Experiencing a severe weather event increases concern about climate change. *Frontiers in Psychology*, 10(FEB).
<https://doi.org/10.3389/fpsyg.2019.00220>
- Bhutta, Z. A., Bhutta, S. Z., Raza, S., and Sheikh, A. T. (2022). Addressing the human costs and consequences of the Pakistan flood disaster. *Lancet (London, England)*, 400(10360), 1287–1289. [https://doi.org/10.1016/S0140-6736\(22\)01874-8](https://doi.org/10.1016/S0140-6736(22)01874-8)
- Bompotas, A., Anagnostopoulos, C., Kalogeras, A., Kalogeras, G., Mylonas, G., Stefanidis, K., Alexakos, C., and Dandoulaki, M. (2022). *A Civil Protection Early Warning System to Improve the Resilience of Adriatic-Ionian Territories to Natural and Man-made Risk*.
<http://arxiv.org/abs/2207.13941>
- Chou, J. S., Yang, K. H., and Ren, T. C. (2015). Ex-post evaluation of preparedness education in disaster prevention, mitigation and response. *International Journal of Disaster Risk Reduction*, 12, 188–201.
<https://doi.org/10.1016/J.IJDRR.2015.01.002>
- Commission on Revenue Allocation (CRA). (2022). *Kenya County Fact Sheets, Third Edition*.
<https://cra.go.ke/wp-content/uploads/2022/06/Kenya-County-fact-sheets-Report-Final-Res.pdf>
- Cools, J., and Demetrio Innocenti, M. (2015). *Flood early warning in practice: lesson learnt from a comparative analysis (input paper)*. Prepared for the 2015 global assessment report on disaster risk reduction.
- Coughlan de Perez, E., Berse, K. B., Depante, L. A. C., Easton-Calabria, E., Evidente, E. P. R., Ezike, T., Heinrich, D., Jack, C., Lagmay, A. M. F. A., Lendelvo, S., Marunye, J., Maxwell, D. G., Murshed, S. B., Orach, C. G., Pinto, M., Poole, L. B., Rathod, K., Shampa, and Van Sant, C. (2022). Learning from the past in moving to the future: Invest in communication and response to weather early warnings to reduce death and damage. In *Climate Risk Management (Vol. 38)*. Elsevier B.V.
<https://doi.org/10.1016/j.crm.2022.100461>

- County Government of Kisumu. (2020). *Kisumu County Climate Change Risk and Vulnerability Assessment Report*. https://www.kisumu.go.ke/wp-content/uploads/CCV-Report-FINAL_FINAL-23thNov2020.pdf
- County Government of Kisumu. (2023a). *Kisumu County Integrated Climate Change Action Plan 2022-2027*.
- County Government of Kisumu. (2023b). *Kisumu County Participatory Climate Risk Assessment Report. Financing Locally-Led Climate Action (FLLoCA) Program*.
- CRED, and UNISDR. (2015). *The Human Cost of Natural Disasters: A global perspective*.
- Creswell, J., and Creswell, J. D. (2018). *Research Design Qualitative, Quantitative and Mixed Approaches* (Fifth). SAGE.
- Díaz, P., Aedo, I., and Herranz, S. (2014a). Citizen Participation and Social Technologies: Exploring the Perspective of Emergency Organizations. *Information Systems for Crisis Response and Management in Mediterranean Countries. ISCRAM-Med 2014*, 196, 85–97.
- Díaz, P., Aedo, I., and Herranz, S. (2014b). Citizen Participation and Social Technologies: Exploring the Perspective of Emergency Organizations. *Lecture Notes in Business Information Processing*, 196, 85–97. https://doi.org/10.1007/978-3-319-11818-5_8
- Dube, K., Nhamo, G., and Chikodzi, D. (2022). Flooding trends and their impacts on coastal communities of Western Cape Province, South Africa. *GeoJournal*, 87, 453–468. <https://doi.org/10.1007/s10708-021-10460-z>
- Dutta, R., and Basnayake, S. (2018). Gap assessment towards strengthening early warning systems. *International Journal of Disaster Resilience in the Built Environment*, 9(2), 198–215. <https://doi.org/10.1108/IJDRBE-11-2016-0051>
- Ersoy, Ş., and Koçak, A. (2016). Disasters and earthquake preparedness of children and schools in Istanbul, Turkey. *Geomatics, Natural Hazards and Risk*, 7(4), 1307–1336. https://doi.org/10.1080/19475705.2015.1060637/ASSET/4F45B4B2-1834-4EDB-A234-61886DC9D46B/ASSETS/IMAGES/TGNH_A_1060637_F0005_OC.JPG
- Fakhruddin, S. H. M., Kawasaki, A., and Babel, M. S. (2015). Community responses to flood early warning system: Case study in Kajjuri Union, Bangladesh. *International Journal of Disaster Risk Reduction*, 14, 323–331. <https://doi.org/10.1016/j.ijdr.2015.08.004>

- Floodlist. (2016, January 11). *UN – 1995 to 2015, Flood Disasters Affected 2.3 Billion and Killed 157,000 – FloodList*. <https://floodlist.com/dealing-with-floods/flood-disaster-figures-1995-2015>
- Floodlist. (2024, May 1). *Kenya – Floods Displace Thousands of Households in Mandera and Kisumu – FloodList*. <https://Floodlist.Com/Africa/Kenya-Floods-Kisumu-Mandera-April-2023>. <https://floodlist.com/africa/kenya-floods-kisumu-mandera-april-2023>
- Frost, R. (2023, October 7). From sirens to text messages: Why extreme weather warnings are needed more than ever | Euronews. *Euronews*. <https://www.euronews.com/green/2023/10/07/from-sirens-to-text-messages-why-extreme-weather-warnings-are-needed-more-than-ever>
- Glago, F. J. (2021). Flood Disaster Hazards; Causes, Impacts and Management: A State-of-the-Art Review. In *Natural Hazards - Impacts, Adjustments and Resilience*. <https://doi.org/DOI:http://dx.doi.org/10.5772/intechopen.95048>
- GOK. (2018). *National Climate Change Action Plan (Kenya): 2018-2022. Volume 3: Mitigation Technical Analysis Report*. www.environment.go.ke
- GOK. (2019). *Water Resources Authority Strategic Plan 2018-2022*. <chrome-extension://efaidnbnmnnibpcajpcgiclfndmkaj/https://faolex.fao.org/docs/pdf/ken207659.pdf>
- GOK. (2021). *Submission on the General Comment on Children’s Rights and the Environment with a Special Focus on Climate Change*.
- Hailey, J., and James, R. (2004). “Trees die from the top”: International perspectives on NGO leadership development. *Voluntas*, 15(4), 343–353. <https://doi.org/10.1007/s11266-004-1236-8>
- Hammood, W. A., @Asmara, S. M., Arshah, R. A., Hammood, O. A., Halbusi, H. Al, and Al-Sharafi, M. A. (2020). Factors influencing the success of information systems in flood early warning and response systems context. *Telkomnika (Telecommunication Computing Electronics and Control)*, 18(6), 2956–2961. <https://doi.org/10.12928/TELKOMNIKA.v18i6.14666>
- Hanchey, A., Schnall, A., Bayleyegn, T., Jiva, S., Khan, A., Siegel, V., Funk, R., and Svendsen, E. (2021). Notes from the Field: Deaths Related to Hurricane Ida Reported by Media - Nine States, August 29-September 9, 2021. *MMWR. Morbidity and Mortality*

Weekly Report, 70(39), 1385–1386.
<https://doi.org/10.15585/MMWR.MM7039A3>

ICHA. (2021). *The Status of Flood Early Warning Communication in Lower Tana and Athi Basins Authors: Early Warning Communication for Enhanced Anticipatory Disaster Risk* (2).

IFRC. (2009). *World Disasters Report. Focus on early warning, early action.* https://issuu.com/ifrc/docs/world_disasters_report_2009

IFRC. (2012). *Community early warning systems: guiding principles.* www.ifrc.org

IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* <https://www.ipcc.ch/report/ar5/syr/>

Islam, A. R. Md. T., Abdullah Al Mamun, Md Naimur Rahman, Mst Yeasmin Akter, Musabber Ali Chisty, G.M. Monirul Alam, Javed Mallick, and Md Salman Sohel. (2024). A cost-benefit analysis of flood early warning system: Evidence from lower Brahmaputra River Basin, Bangladesh. *International Journal of Disaster Risk Reduction*, 47(106). <https://doi.org/10.1016/j.ijdrr.2020.101534>

Kiptum, A., Mwangi, E., Otieno, G., Njogu, A., Kilavi, M., Mwai, Z., MacLeod, D., Neal, J., Hawker, L., O'Shea, T., Saado, H., Visman, E., Majani, B., and Todd, M. C. (2023). Advancing operational flood forecasting, early warning and risk management with new emerging science: Gaps, opportunities and barriers in Kenya. *Journal of Flood Risk Management*. <https://doi.org/10.1111/jfr3.12884>

KNBS. (2019). *Kenya Population and Housing Census Volume 1: Population by County and Subcounty.*

Kozlov, M. (2021). Hurricane Ida forces Louisiana researchers to rethink their future. *Nature*, 597(7876), 313–314. <https://doi.org/10.1038/D41586-021-02456-Z>

Kreibich, H., Pech, I., Schröter, K., Müller, M., and Thielen, A. H. (2016). New insights into flood warning and emergency response from the perspective of affected parties. *Natural Hazards and Earth System Sciences*. <https://doi.org/10.5194/nhess-2016-133>

Kumar, S., Jain, S. K., and Gurrupu, S. (2020, February). Challenges and Recent Developments in Flood Forecasting in India. *Roorkee Water Conclave 2020*. <https://www.researchgate.net/publication/374029530>

- Lumbroso, D. (2018). How can policy makers in sub-Saharan Africa make early warning systems more effective? The case of Uganda. *International Journal of Disaster Risk Reduction*, 27, 530–540. <https://doi.org/10.1016/j.ijdr.2017.11.017>
- Lumbroso, D., Rance, J., Pearce, G., and Wade, S. (2014). *Final report: Science for Humanitarian Emergencies and Resilience (SHEAR) scoping study*. https://doi.org/10.12774/eod_cr.june2014.lumbrosoetal
- Masese, A. G., Neyole, E. M., Nicholas, O., Masese, A., Neyole, E., and Ombachi, N. (2016). Loss and Damage from Flooding In Lower Nyando Basin, Kisumu County, Kenya. *International Journal of Social Science and Humanities Research*, 4(3), 9–22. <https://www.researchgate.net/publication/308631798>
- MoALF. (2017). *Climate Risk Profile for Kisumu County. Kenya County Climate Risk Profile Series*. http://hdr.undp.org/sites/default/files/knhd_report_2013.pdf
- Moisès, D. J., and Kunguma, O. (2023). Strengthening Namibia's Flood Early Warning System through a Critical Gap Analysis. *Sustainability (Switzerland)*, 15(1). <https://doi.org/10.3390/su15010524>
- Mustafa, D., Gioli, G., Qazi, S., Waraich, R., Rehman, A., and Zahoor, R. (2015). Gendering flood early warning systems: The case of Pakistan. *Environmental Hazards*, 14(4), 312–328. <https://doi.org/10.1080/17477891.2015.1075859>
- New, M. , D., Reckien, D., Viner, C., Adler, S.-M., Cheong, C., Conde, A., Constable, E., Coughlan de Perez, A., Lammel, R. M., B. Orlove, and W. Solecki. (2022). Decision-Making Options for Managing Risk. In *Climate Change 2022 – Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 2539–2654). Cambridge University Press. <https://doi.org/10.1017/9781009325844.026>
- Niang, I., Ruppel, M. A., Abdrabo, M. A., Essel, C., Lennard, J., Padgham, J., and Urquhart, P. (2014). Africa. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1199–1265). Cambridge University Press.
- Northfield, A., Cawood, M., and Wang, H. (2021). *Testing the effectiveness of your warning system without having a flood*.

- OCHA. (2024). *Kenya: Heavy rains and flooding update Flash Update #6*.
<https://www.unocha.org/publications/report/kenya/kenya-heavy-rains-and-flooding-update-flash-update-6-17-may-2024>
- Odero, N. A., and Mahiri, I. (2022). The Complacency of Flood Victims, Socio Economic Factors, and Effects and Vulnerabilities of Floods in Lower Kano Plains, Kisumu County, Kenya. *International Journal of Disaster Risk Management*, 4(2), 59–76.
<https://doi.org/10.18485/ijdrm.2022.4.2.4>
- Office of the Auditor General. (2023). *Response Audit Report of the Auditor General on Response-To-Floods-in-Kenya*.
- Ogie, R. I., Adam, C., and Perez, P. (2020). A review of structural approach to flood management in coastal megacities of developing nations: current research and future directions. In *Journal of Environmental Planning and Management* (Vol. 63, Issue 2, pp. 127–147). Routledge.
<https://doi.org/10.1080/09640568.2018.1547693>
- Ojina, E. (2024, May 8). Explainer: Why Kisumu often floods | Nation. *Nation Newspaper*.
<https://nation.africa/kenya/counties/kisumu/explainer-why-kisumu-often-floods-4616562>
- Okayo, J., Odera, P., and Omuterema, S. (2015). Socio-economic characteristics of the community that determine ability to uptake precautionary measures to mitigate flood disaster in Kano Plains, Kisumu County, Kenya. *Geoenvironmental Disasters*, 2(1). <https://doi.org/10.1186/s40677-015-0034-5>
- Omukuti, J., Megaw, A., Barlow, M., Altink, H., and White, P. (2021). The value of secondary use of data generated by non-governmental organisations for disaster risk management research: Evidence from the Caribbean. *International Journal of Disaster Risk Reduction*, 56. <https://doi.org/10.1016/j.ijdr.2021.102114>
- Opere, A. (2013). Floods in Kenya. In *Developments in Earth Surface Processes* (Vol. 16, pp. 315–330). Elsevier B.V. <https://doi.org/10.1016/B978-0-444-59559-1.00021-9>
- Pappenberger, F., Cloke, H. L., Parker, D. J., Wetterhall, F., Richardson, D. S., and Thielen, J. (2015). The monetary benefit of early flood warnings in Europe. *Environmental Science and Policy*, 51, 278–291. <https://doi.org/10.1016/j.envsci.2015.04.016>
- Parker, D. J., Priest, S. J., and Tapsell, S. M. (2009). Understanding and enhancing the public's behavioural response to flood warning information. *Meteorological Applications*, 16(1), 103–114. <https://doi.org/10.1002/met.119>

- Payet, M., and Forestier, Y. Le. (2021, July 21). *Germany questions warning system after deadly floods*. <https://phys.org/news/2021-07-germany-deadly.html>
- Perera, D., Agnihotri, J., Seidou, O., and Djalante, R. (2020). Identifying societal challenges in flood early warning systems. *International Journal of Disaster Risk Reduction*, 51. <https://doi.org/10.1016/j.ijdrr.2020.101794>
- Perera, D., Seidou, O., Agnihotri, J., Mehmood, H., and Rasmy, M. (2020). Challenges and Technical Advances in Flood Early Warning Systems (FEWSs). In *Flood Impact Mitigation and Resilience Enhancement*. IntechOpen. <https://doi.org/10.5772/intechopen.93069>
- Perera, D., Seidou, O., Agnihotri, J., Wahid, A., and Rasmy, M. (2019). *Flood Early Warning Systems: A Review Of Benefits, Challenges And Prospects*. <https://doi.org/10.13140/RG.2.2.28339.78880>
- Prior, T., and Eriksen, C. (2013). Wildfire preparedness, community cohesion and social-ecological systems. *Global Environmental Change*, 23(6), 1575–1586. <https://doi.org/10.1016/j.gloenvcha.2013.09.016>
- Raburu, Khisa, P. ;, and Masese, F. O. (2012). Background information on Nyando Wetland. In P. O. Raburu, J. B. Okeyo-Owuor, and F. Kwena (Eds.), *Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*. Kenya Disaster Concern - VIREC - UNDP. <http://hdl.handle.net/1834/7723>
- Rana, I. A., Bhatti, S. S., and Jamshed, A. (2021). Effectiveness of flood early warning system from the perspective of experts and three affected communities in urban areas of Pakistan. *Environmental Hazards*, 20(3), 209–228. <https://doi.org/10.1080/17477891.2020.1751031>
- Samansiri, S., Fernando, T., and Ingirige, B. (2023). Critical Failure Factors of Flood Early Warning and Response Systems (FEWRS): A Structured Literature Review and Interpretive Structural Modelling (ISM) Analysis. *Geosciences (Switzerland)*, 13(5). <https://doi.org/10.3390/geosciences13050137>
- Samant Raja, D., and Narasimhan, N. (2013). *Inclusive Disaster and Emergency Management for Persons with Disabilities. A review of needs, challenges, effective policies, and practices*. <https://www.humanitarianlibrary.org/sites/default/files/2022/06/Inclusive%20Disaster%20and%20Emergency%20Management%20for%20Persons%20with%20Disabilities-September%2016%202013-1.pdf>

- Seneviratne, S. I. , X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, I. Iskandar, J. Kossin, S. Lewis, F. Otto, I. Pinto, M. Satoh, S.M. Vicente-Serrano, M. Wehner, and B. Zhou. (2021). Weather and Climate Extreme Events in a Changing Climate. In *Climate Change 2021 - The Physical Science Basis* (pp. 1513–1766). Cambridge University Press. <https://doi.org/10.1017/9781009157896.013>
- Shah, A. A., Ullah, A., Khan, N. A., Khan, A., Tariq, M. A. U. R., and Xu, C. (2023). Community social barriers to non-technical aspects of flood early warning systems and NGO-led interventions: The case of Pakistan. *Frontiers in Earth Science*, 11. <https://doi.org/10.3389/feart.2023.1068721>
- Shah, A. A., Ullah, A., Khan, N. A., Pal, I., Alotaibi, B. A., and Traore, A. (2022a). Gender Perspective of Flood Early Warning Systems: People-Centered Approach. *Water (Switzerland)*, 14(14). <https://doi.org/10.3390/w14142261>
- Shah, A. A., Ullah, A., Khan, N. A., Pal, I., Alotaibi, B. A., and Traore, A. (2022b). Gender Perspective of Flood Early Warning Systems: People-Centered Approach. *Water (Switzerland)*, 14(14). <https://doi.org/10.3390/w14142261>
- Shah, A. A., Ye, J., Abid, M., Khan, J., and Amir, S. M. (2018). Flood hazards: household vulnerability and resilience in disaster-prone districts of Khyber Pakhtunkhwa province, Pakistan. *Natural Hazards*, 93(1), 147–165. <https://doi.org/10.1007/s11069-018-3293-0>
- Sneddon, A. (2019, July 31). *Gender and Early Warning Systems: Lessons from Nepal and Peru - Zurich Climate Resilience Alliance*. CRA. <https://zcralliance.org/blogs/gender-and-early-warning-systems-lessons-from-nepal-and-peru/>
- Speis, P. D., Andreadakis, E., Diakakis, M., Daidassi, E., and Sarigiannis, G. (2019). Psychosocial vulnerability and demographic characteristics in extreme flash floods: The case of Mandra 2017 flood in Greece. *International Journal of Disaster Risk Reduction*, 41. <https://doi.org/10.1016/j.ijdrr.2019.101285>
- Sufri, S., Dwirahmadi, F., Phung, D., and Rutherford, S. (2020). A systematic review of Community Engagement (CE) in Disaster Early Warning Systems (EWSs). In *Progress in Disaster Science* (Vol. 5). Elsevier Ltd. <https://doi.org/10.1016/j.pdisas.2019.100058>
- Thieken, A. H., Bubeck, P., Heidenreich, A., Von Keyserlingk, J., Dillenardt, L., and Otto, A. (2023). Performance of the flood warning system in Germany in July 2021 - insights from affected residents. *Natural Hazards and Earth System Sciences*, 23(2), 973–990. <https://doi.org/10.5194/NHESS-23-973-2023>

- UNDP. (2004). *A global report reducing disaster risk: A challenge for development*. United Nations Development Programme.
- UNDP. (2016a). *Getting to the Last Mile in Least Developed Countries*. www.undp.org
- UNDP. (2016b). *Knowledge Attitudes and Practice Study on Climate Change Japan-Caribbean Climate Change Project*. https://www.adaptation-undp.org/sites/default/files/resources/knowledge_attitudes_and_practice_study_on_climate_change_in_belize.pdf
- UNDRR, and WMO. (2024, April 5). *Community engagement and its vital role in EWS implementation | UNDRR*. <https://www.undrr.org/news/community-engagement-and-its-vital-role-early-warning-systems-implementation>
- UNEP. (2012). *Early Warning Systems A State of the Art Analysis and Future Directions*. www.unep.org
- UNICEF. (2018). *Kenya Floods Response Update - 8 June 2018*. <chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.unicef.org/media/75011/file/Kenya-Flash-Update-8-June-2018.pdf>
- UNISDR. (2004). *Terminology: Basic terms of disaster risk reduction*.
- UNISDR. (2009). *UNISDR Terminology on Disaster Risk Reduction*. www.preventionweb.net
- UNISDR. (2015). *Sendai Framework for Disaster Risk Reduction 2015 - 2030*.
- United Nations. (2006). *Global Survey of Early Warning Systems An assessment of capacities, gaps and opportunities towards building a comprehensive global early warning system for all natural hazards*. www.unisdr.orgwww.unisdr-earlywarning.org
- United Nations. (2015). *Paris Agreement*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf
- United Nations Office for Disaster Risk Reduction and World Meteorological Organization. (2023). *Global Status of Multi-Hazard Early Warning Systems 2023*. www.public.wmo.int
- Wagner, S., Souvignet, M., Walz, Y., Balogun, K., Komi, K., Kreft, S., and Rhyner, J. (2021). When does risk become residual? A systematic review of research on flood risk management in West Africa. In *Regional Environmental Change* (Vol. 21, Issue 3). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1007/s10113-021-01826-7>

WHO. (2024). *Floods*. https://www.who.int/health-topics/floods#tab=tab_1

WMO. (2021). *Floods*. <https://wmo.int/about-us/world-meteorological-day/wmd-2020/floods>

Wyns, A. (2022). Disaster diplomacy in the wake of the 2022 Pakistan floods. In *The Lancet. Planetary health* (Vol. 6, Issue 11, pp. e855–e856). NLM (Medline). [https://doi.org/10.1016/S2542-5196\(22\)00240-6](https://doi.org/10.1016/S2542-5196(22)00240-6)

Appendices

Appendix 1: Questionnaires for Focus Group Discussion and Key Informant Interviews

Focus Group Discussion Interview Guide on Early warning systems

Consent to take part in research:

I..... voluntarily agree to participate in this research study.

I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind. I understand that this research is for academic purposes and I will not directly benefit from participating in the study

I agree to my interview being audio and visually recorded.

I understand my identity will remain anonymous and all the information provided for this study will be treated confidentially.

Signature of research participant_____

Background Information:

Name of Sub County:

Name of Ward:

Name of Village:

Date of interview:

Time of interview:

Flooding

1. How has climate change affected the community?
2. How frequently does the floods occur in a year? (Specify the months in which the floods occur; how many times in a year, how often has the floods occurred in the last 10 years?)
3. What are the causes of floods in your area?
4. When the floods occur where do you move to?
5. How long do you stay in the areas where you move to?
6. How long does the flood last?

7. Do you receive any help when it floods? (If yes from who?)
8. What kind of aid do you receive?

Barriers to accessing early warning messages

1. Are you aware about EW messages?

If yes specify

2. How do you receive the early warning messages?
3. What information do you receive specifically on rainfall and floods?
4. Do the early warning messages specify the extent of flooding and when they will occur?
5. Do the EW messages advise you on when to evacuate? If yes, where do you evacuate to?
6. Do you receive the warnings on time?
7. How helpful are these early warning messages?
8. Are the early warning messages specific to Kisumu County?
9. Does the community possess indigenous knowledge that they use to forecast floods?? (specify these IK)
10. Do you receive any alerts or warning messages before floods occur?
11. How accurate are the warnings received?
12. How are the warning messages used by the community in terms of flood preparedness?
13. What action is taken by the community after receiving the warning messages?
14. Have you received any training on disaster preparedness and management?

Factors impeding comprehension and inclusivity of early warning messages

1. Which language is the early warning message broadcasted in?
2. Can you understand the language used?
3. Is the community involved in preparing the early warning messages?
4. Are some community members part of disaster committee?
5. Does your area have a disaster or emergency preparedness plan?
6. How many evacuation centres are available in your area?
7. Do the early warning messages reach (accessibility) all members of the community including the vulnerable members (PWDs, elderly, pregnant women)? (if yes ask how)
8. If no what can be done to improve accessibility?
9. Which channels are most effective in reaching most members of the community? (TV, Radio, mobile app etc)

Gender and EWS

1. How does flooding affect the different genders?
2. How are women involved during preparation and dissemination of EW messages?
3. How has gender based violence been included in disaster management training?

Government involvement

1. What role does the county/national government play in disaster management? (distributing supplies e.g. food, blankets etc; evacuation, community awareness and education on disaster management)
2. Is the community willing to take preventive measures to avoid flooding? (Specify these preventive measures)
3. How does the county government work with other stakeholders in preparing the community for the forecasted disaster?
4. Are you aware of any law or policy on disaster management in Kisumu County?

Interview Schedule for Key Informant Interviews

Name of respondent:

Title:

Introduction: (brief introduction of what the study entails)

1. What is your view on climate change and its effects on the community?
2. Role of county/national government in disaster preparedness?
3. Does Kisumu County have a disaster or emergency preparedness plan?
4. When are the warning messages broadcasted?
5. Which department is responsible for forecasting and sending out the early warning messages?
6. What training does the community have on disaster preparedness?
7. What action does the community take once they have received the early warning messages?
8. How is information shared and coordinated among the various departments and the recipient community?
9. How is indigenous knowledge incorporated when preparing the early warning messages?
10. What are the roles and responsibilities of the various department in preparing for disasters
11. Does the county government have a budget allocation for preparing and disseminating early warning messages?
12. Does the county government have access to sufficient and timely weather forecasting data?
13. How does the county government partner with other stakeholders in preparation and dissemination of early warning messages?
15. How are the marginalized groups included in the preparation of early warning messages?
16. How can gender perspectives be integrated during the design of the early warning systems?

Appendix 2: Photos from the Fieldwork



Image 1: Desiltation of River Mahenya



Image 2: Women only FGD held at Angola Community Hall on June 24, 2024



Image 3: A house constructed using iron sheets. Due to the perennial floods, iron sheets are the more preferred housing material used for construction since it can withstand the floods compared to houses made from mud (picture on right hand side).



Image 4: From Left Dr. Olaka, Dr. Obiero, Mr. Edwin John (Key informant Red Cross), Mr. James Nyagol, Senior Climate Change Officer, County Government of Kisumu pose for a photo at the end of the key informant interview held at Red Cross Offices on June 5, 2024, in Kisumu County.



Image 5: Mixed FGD held on June 28, 2024, at Kolwa East



Image 6: A housing structure destroyed by floods