Urban Flooding in the Cities of Kisumu, Mombasa, and Nairobi, Kenya: Causes, Vulnerability Factors, and Management

Stanley Omuterema Oluchiri[1]

[1]somuterema@mmust.ac.ke

[1]Masinde Muliro University of Science and Technology, Kenya

https://doi.org/10.51867/ajernet.6.1.29

ABSTRACT

This research investigates the complex urban flooding dynamics of Kisumu together with Mombasa and Nairobi cities in Kenya. Since both human-caused urban growth and climate change effects simultaneously produce more non-absorptive surfaces. conditions have worsened globally. The problem of urban flooding in Africa deepens when countries fail to plan their cities correctly and continue to deteriorate their environments. The recent floods in Kenya have produced catastrophic outcomes which make it vital to implement strong flood management methods that adhere to national climate action plans. Based on environmental justice and urban metabolism theories, this study employed qualitative and descriptive research methods to investigate urban flooding in Kisumu, Mombasa, and Nairobi, Kenya. It relied on purposive sampling to select data sources, including government reports, NGO publications, and academic journals. Primary and secondary data were analyzed through structured data analysis to categorize findings systematically. The research utilized qualitative techniques for in-depth exploration and descriptive methods to explain factual data. An online review of databases spanning a decade ensured data reliability, while expert insights from urban planners and flood management officials enhanced methodological rigour. Experts have proved that economic differences create more exposure to flooding within lower-income neighbourhoods besides failing institutions in planning and communication that heighten risks. The irregular rainfall patterns of global warming create additional stress for urban flood operations. Through the combination of urban metabolism and environmental justice concepts the research study demonstrates how resources get distributed unfairly and environmental risks affect selected populations unequally. The research indicators show the need to merge disaster risk reduction requirements directly into socio-economic urban development programmes. This research demonstrates the need for better community participation alongside improved institutions and sustainable urban development programmes which need to protect urban areas from floods. Future investigations should concentrate on building adaptable urban planning systems which dynamically react to environmental changes and social-economic fluctuations to include every community segment within flood risk approaches. The process requires the examination of advanced technology systems for forecasting floods as well as building community-driven resilience methods to achieve better disaster response control at a local level.

Keywords: Climate Change, Disaster Management, Urban Flooding, Urbanization, Vulnerability

I. INTRODUCTION

The world faces an increasingly serious challenge from urban flooding which gets worse due to climate change together with fast urban growth. Urban development creating more impermeable surfaces across the world causes natural water absorption interruptions that raise flood threats (UN-Habitat, 2016). The occurrence triggers severe rainfall events that produce substantial socio-economic effects because of population increases in cities (Hallegatte et al., 2013). Advanced disaster management strategies must be developed to work in different global settings because they need infrastructure systems that function effectively during or after flood events.

Urban flooding throughout Africa worsens due to both quickened urbanisation alongside environmental climate variations. The ongoing population growth within African urban zones drives inhabitants to establish settlements in flood-prone areas but formal protective infrastructure reaches only limited areas within impoverished settlements. (Pelling & Wisner, 2012. The combination of insufficient urban development planning and destroyed natural barriers which effectively blocked floods (Satterthwaite et al., 2007) makes the situation worse. Records of flood events show their destructive impact on human lives along with economic losses making it essential to develop specific flood control measures and urban development practises across the area according to Douglas et al. (2008).

The cities of Kisumu together with Mombasa and Nairobi face major flooding risks because of how they are situated and the large number of people who live there. Rural-urban migration based on economic interests has produced densely populated cities where many residents face poverty because they work in informal sectors (Oyvat & Githinji, 2019). The flash flood disaster from March to April 2024 caused extensive human losses including 169 initially confirmed fatalities and a later count of 294 deaths and 162 missing persons 101,132 displaced people and 151 closed schools (Avery, 2024; Onyango et al., 2024). Nairobi's informal settlements host an excessive population of displaced

persons that reveals substantial differences between population resilience groups. The present challenges in drainage, improper land usage and land degradation need urgent solutions because they create an immediate and critical situation (Avery, 2024). Urban planning together with disaster management strategies needs improvement to help reduce vulnerability and support recovery while following Kenya's Nationally Determined Contributions (NDC) fulfilment through Sustainable Development Goals (Government of Kenya, 2023).

Global urban flood management shows major weaknesses which academic researchers attribute to African rapid urbanisation and deficient Kenyan urban planning alongside degraded land quality and inadequate drainage systems.

1.1 Statement of the Problem

Although urbanization indicates economic development, it is a sensitive process in determining the structure and sustainability of the development. The occupancy of the urbanized areas determines the location for residential and informal settlement, indicating the coexistence of the rich and poor, the distribution of resources, and the state of infrastructure. Consequently, development gaps will increase risks associated with climate change, in this case, flooding, if no sustainable structures are in place. Moreover, climate change, which Kenya is not exempted from, has raised concerns about the unpredictability of long and short rains (Okaka & Odhiambo, 2019). Flood disasters have been on the increase in urban areas in Kenya. The frequency and severity are alarming, considering the loss of lives and property and the damage caused to infrastructure.

Over the past few decades, some studies have been done to enhance understanding of the nature of flooding, its causes, vulnerability, and management strategies in Kenyan urban areas. However, they provide little information on the contribution of hydrological factors to flooding in the affected areas. Insufficient drainage investigations, human-caused factors and climate change influences on flood disasters remain inadequate in scientific exploration (Douglas et al., 2008; Satterthwaite et al., 2007; Zhang, 2013). The role of lack of proper drainage, anthropogenic factors, and climate change in exacerbating flood disasters have also not been exhaustively examined. With rapid urbanization, the vulnerability of communities in the affected areas has continued to change. The changes in land use for settlement and development projects have exposed many sites to flood risks. As a result, these places suffer geographical and institutional vulnerabilities that require to be evaluated for effective flood interventions. There is a dearth in knowledge and understanding of the various vulnerabilities in the flood-affected areas. Management of floods in these areas is, therefore, a challenge. The knowledge gaps can be addressed by interventions from the analysis undertaken in this paper.

1.2 Research Objective

i. To determine urban flooding elements that make Kenyan citizens more susceptible to damage.
ii. To explore community flood risk in Kenyan urban areas while accounting for fast urbanisation trends along with land use adjustments.

II. LITERATURE REVIEW

2.1 Theoretical Review

2.1.1 Environmental Justice Theory

Several theoretical contexts demonstrate the relationship between urban flooding vulnerability and management strategies. However, the most relevant is the principle of local, regional, or national action at an appropriate scale. Douglas et al. (2008) apply this principle through the environmental justice theory, which explains that benefits and hazards associated with the environment should be distributed equally across people regardless of their vulnerability identities. The theory explains that environmental protection should be fairly distributed, recognizing that people living in poverty, with a disability, or within marginalized communities would be significantly impacted by urban flooding in terms of livelihood, health, and safety. Significantly, the theory advocates for inclusive participation in decision-making processes and development of environmental protection policies, underscoring the roles of various groups from the community to international levels. It guides the use of available resources, including those from community organizations, in managing various types of floods. National governments, regional bodies, and international consortia have a role in managing urban floods. The principle also advocates preserving natural floodplains as buffers of flood waters and restricts construction activities in such areas. Coupled with this principle is the viewpoint by Amaoko (2012) that managing flood risks is dynamic and requires innovative solutions that respond to changes in space and time. Participatory engagement and coordination are critical at the correct scale and should be linked with the implementation, monitoring, and evaluation framework.

2.1.2 Urban Metabolism Theory

The urban metabolism theory attempts to explain the challenges of urban area development in increasing flooding risks within the areas. The theory views a city from a human metabolism perspective (Zhang, 2013). A thriving

environment has a balanced system, with a sustainable controlled intake of resources and appropriately managed waste generation. However, the rapid development of the areas distorts this balance from both avenues. The fast development of roads, industries, and buildings compromises the nature of land, forests, and drainage systems through impermeable surfaces. Consequently, the increased metabolism pace increases waste capacity, compromising the waste management channels and increasing pressure on the systems that aim to service the ever-growing population in urban areas. Modernization approaches indicate that urbanization has transformed economic and social factors (Marsh, 2014). It has also led to socio-spatial inequalities in communities. This persists in developing countries despite efforts to entrench Sustainable Development Goals (SDGs), specifically SDG 11, which focuses on making cities more inclusive, safe, and resilient (UN-Habitat, 2016; United Nations, 2017). The pursuit of sustainable urbanization is a goal of many low and middle-income countries. Policies for meeting the objectives often fall short due to disaster risks, including flooding. In order to design effective strategies, it is essential to understand the extent of risks, vulnerability, and local capacity (Desouza & Flanery, 2013; Flower et al., 2018). In such situations, the affected people in modernized urban societies develop what is referred to as "self-flexibility" to anticipate climate threats and adopt measures to mitigate them (Marsh, 2014). The current study examines the causes of flooding and existing vulnerabilities. This provides a better understanding of the required options for lasting interventions.

2.2 Empirical Review

2.2.1 Urban Flooding Elements That Make Citizens More Susceptible to Damage

Economic development has been the primary objective of countries for urban redevelopment during the past years. Rapid development causes flooding areas because urban developers neglect to support sustainable and equitable urban expansion (Balaian et al., 2024). The economic status of the nation depends on cash flow which attracts the majority of people to live in these cities. The migration mechanism supports human involvement in converting innovative thoughts into business ventures and investment projects that accelerate national economic growth. The intense influx of people as well as ideas causes localised infrastructure congestion to exceed anticipated levels as mentioned in initial planning documents and resource allocation guidelines. Most people opt for cheap living while choosing undeveloped establishments that welcome many residents before they promote themselves when their careers improve their income level.

Almost everyone who property-hunts in these risk areas eventually creates their permanent base there. Studies show by Rentschler et al. (2023) that areas with high flood risk attract more settlers than low flood danger zones while using East Asia as their main example. Every low and middle-income country experiences this regular occurrence. Mumbai city stands as a coastal metropolitan area that surrounds four different rivers. The commercial expansion of the area puts economic stability at risk because excessive monsoon rainfall and high tides result from deteriorated drainage systems (Bhide, 2024). The research by Smith (2023) analyses the situation in coastal cities through an examination of Jakarta. The population of the city depends primarily on piped water supplies to meet their needs but only 4% of the population enjoys access to stable sewage services. The leakage of solid waste storage tanks into flowing rivers brings dangerous mass and pathogenic waste materials to unprotected water supplies leading to adverse health consequences for people who depend on the water as their main water source. The government of this city implemented different flood mitigation strategies that involved better water drainage systems watertight sea walls and flood pumping stations in order to reduce population dependency on faulty water sources. Most urban planning authorities alongside infrastructure decision-makers have demonstrated an inability to regulate urban population expansion which results in greater flood vulnerability.

2.2.2 Community Flood Risk in Urban Areas While Accounting for Fast Urbanisation Trends Along with Land Use Adjustments

The problem of urban flooding increases in prevalence across the African continent. Dodman et al. (2017) state that limited scholarly work and statistical analysis exist to examine problems affecting African metropolitan areas. Rapid migration continues to be a problem in numerous African cities as they seek urban development solutions. Failure to document these issues hinders organisations' responsibility for future policy development and project control. Different authors have expressed serious concern about the connection between urban growth and flooding. According to the African Aid Report from 2006, poor citizens described their experiences when African cities flooded. Several case studies about group dwellers are examined in the article starting with slums located in Lagos' coastal area and continuing with slum communities formed in Nairobi and Kampala. Most populations now practise flood-preparedness techniques after experiencing rising flood frequencies in their settlements. People have devised strategies such as raising children to elevated positions in the house before shifting them to unaffected areas as well as implementing trench digging and water diversion using dykes. Local urban inhabitants show limited awareness about urban floods which enhances their risk of urban flood disasters according to Baddianaah (2023). The situation leads to inadequate and short-term construction of flood prevention systems which create seasonal relief and security for individuals during rainy periods.

According to Vrkic (2024), most East African communities lack suitable structures combined with adequate plans for recovery procedures. The destruction of property along with disrupted living conditions creates greater poverty and settlement vulnerability among residents since they need to choose low-cost homes even though they face future hazards and available warning systems. African urban communities need sustainable and inclusive strategies to combat urban flooding problems**.**

The issue of urban flooding exists in Kenya to the same extent. Numerous major flooding events in Kenya position water-related disasters among the top death-causing factors in the country while other epidemics and droughts also contribute to the problem (United Nations Office for the Coordination of Humanitarian Affairs [UNOCHA], 2019). Legitimate disasters continue to threaten communities because their weak preparedness for floods is a significant factor in their vulnerability. The development of accurate statistical data together with effective resilience-building measures and damage control methods took an extended period before their establishment. Ill-conceived urban population controls combined with inadequate regulation systems have resulted in overcrowding of urban areas by people seeking better lives during periods of expansion. The elevated jobless rate results in the unequal distribution of residential areas in Kenya (Muiruri, 2022). The rates of population increase within cities present substantial social alongside financial problems regarding insufficient living accommodations and infrastructure fatigue according to Sandu and Sukiasyan (2018). The population increase spawns destructive environmental changes together with severe pollution problems which generate additional adverse effects. The issue of urban flooding in Kenya has long been overlooked until it recently became a recognised problem of concern.

Strategies to address urban flooding serve as key concerns for several organisations operating at the international level. Through its partnerships with various United Nations members, the United Nations Environment Programme (UNEP) works to build disaster-resistance capabilities in vulnerable areas hit by flooding. According to recent UNEP reports the organisation has allowed member states of the UN to focus on SDG 6 by enabling them to use present resources for better climate change response and coping mechanisms (UNEP, 2022). Through its objective, the nations have learned to treat citizens as part of the process thus ensuring their inclusion during implementation. The objective aims to enhance clean water accessibility and implement water body protection strategies against pollution. The strategy includes mapping tools with environmental data which enhances regional understanding so the society can create projects that boost their resilience capabilities.

Jiricka-Pürrer & Wachter (2019) emphasises a comprehensive method to solve climate-change-related problems. Multiple disciplines such as weather research, artificial intelligence and climate pattern predictions, data analysis, and resource management tools should be used for dealing with climate change through sustainable project development toward resilience promotion. The strategy has provided countries irrespective of GDP levels to actively contribute to developing urban flood response frameworks which enable existing resource usage without having to adapt solutions to fit cultural or national requirements. According to Staddon et al. (2018), this strategy helps countries develop multiple projects which employ natural elements from wetlands and green roofs to support environmental sustainability and information exchange among nations. Stormwater management projects are likely to diverge from the standard procedures of cities without water bodies yet maintain essential elements after adaptation.

International organisations very seriously focus on climate change as an important global issue. The issue requires multiple organisations along with fireworks which have been established to address it. The World Bank system has actively worked to create sustainable projects that apply to various nations particularly Japan (Kryspin-Watson et al., 2020). The programme provides financial backing and resource support for risk evaluation and sustainable project planning about research and assessment and infrastructure development across nations. The World Bank runs its Climate Resilience Initiative to tackle different climate emergencies including urban floods which currently operate across European nations (World Bank, 2018). The initiative follows an approach distinct from UNEP to emphasise connected participation between communities and available resources for sustainability-based urban development. The initiative works to eliminate community vulnerability through increased access to funding sources that enable local climate projects educational programmes and social network development.

The Sendai Framework in addition to the Paris Agreement on Climate Change and the New Urban Agenda (NUA) represent different frameworks which actively work to control urban flooding. The Sendai Framework established itself in 2015 for Disaster Risk Reduction (DRR) while fostering resilience across local communities' national entities and worldwide institutions (Mannan et al., 2021). The framework has developed national risk assessment capabilities which reduce risks through development plans and policy frameworks. Through these channels, stakeholders can explore disaster management understanding and learning so they become more aware of sustainability while becoming more resilient. Climate change occupies the primary focus of the Paris Agreement as its primary objective. Article 12 within the agreement promotes the distribution of climate change information (Winter & Karvonen, 2022; Tollin et al. 2017; Tollin et al., 2017). Through its terms, the agreement specifies adopting localised approaches to climate change programmes. Through this approach, each member of the agreement obtains power to design climate change programmes that fulfil their cultural requirements along with local needs together with climate characteristics.

Through this approach, nations receive direction to create both short-duration and medium-duration climate action strategies which use existing resources and matching policies and mechanisms. The strategy helps countries develop climate action plans that require reasonable capacity levels while providing effective solutions to their present dangers. Such approaches boost both environmental stability and community involvement during the improvement period.

Different African organisations now adopt climate change policies as a response to environmental challenges. According to Dodman (2017), the high rate of urbanisation in African cities resulted in poor documentation practices for tracking their climate-related issues. The African Union (AU) formed organisations in partnership with three global bodies: the United Nations Development Programme (UNDP) and the African Union Commission (AUC) together with the United Nations Human Settlement Programme (UN-HABITAT). The union functions through mutual support groups to achieve coordinated urban resilience goals. Various programmes like Resilience Initiative Africa (RIA) together with the African Urban Resilience Programme (AURP) support aware city development by disclosing unknown vulnerability factors (AU, 2023). Development of early warning systems and mitigation strategies in African urban flooding reduction efforts is supported by disaster risk reduction programmes which operate within the Southern African Development Community (SADC) and Economic Community of West African States (ECOWAS) continental regions. The organisations work together with national-level organisations through joint initiatives to achieve implementation goals at the community level and promote inclusivity. Community-initiated early warning systems along with disaster preparedness help organisations create time-efficient projects with high levels of effectiveness.

The implementation methods encounter different difficulties even though administrators make ongoing efforts. Multiple African states lack enough resources to achieve development objectives. Most countries need sources of financial assistance from outside to proceed with their projects. Worldwide communities donate money with particular conditions that guide their project support activities (Ricardo, 2019). These elements produce unreliable forecasting and are negatively affected by governmental shifts in politics. Detectable coordination issues exist among stakeholders because multiple engaged parties have roles in the climate action plans. The implementation timeline of the projects becomes delayed by these factors which results in substandard efficiency and insufficient performance abilities. Several obstacles arise when trying to control urban planning because of unanticipated climate change patterns and fast-paced urban growth. All African nations execute their climate action plans according to their present capabilities in order to safeguard inhabitants and lessen urban flood impact strength.

Various strategies have positioned Kenya as a leader in developing the disaster risk reduction office to new heights. The National Disaster Management Authority (NDMA) implements multiple duties to deal with floods that qualify as disasters throughout Kenya. This framework consists of risk assessment along with preparedness and management operations that boost defences against disasters for susceptible communities. Evacuation programmes alongside emergency management plans along with relocation provisions make up this framework because they help communities recover while reducing damage. Other local entities have established collaborative efforts with international and regional groups to help reduce the suffering from flooding. The Kenya Red Cross Society provides emergency services right after floods happen to families affected by water damage (Gichuhi, 2010). These active responses generate real-time information that supports the improvement of existing data accuracy. Flood-prone area mapping along with zoning practices remain part of the sustained resolution plans. The implementation of control systems together with early warning systems functions as an effective method for community alerting and developing preventive strategies that minimise disaster damage intensities.

III. METHODOLOGY

This chapter describes the methodological approach for studying the origins and risks alongside management solutions regarding urban flooding problems in Kenyan cities including Kisumu, Mombasa, and Nairobi. The research relies on qualitative and descriptive research paradigms to conduct an online analysis of both primary and secondary data that reveals complex socioeconomic and environmental factors.

The research study employs a qualitative method to analyse urban flooding components through structured data analysis for interpreting and categorising data findings. Smith (2024) recommends using the qualitative methodology because it delivers extensive information about flooding origins and system vulnerabilities as well as management procedures. According to Lambert and Lambert (2012), the research uses descriptive methods to explain factual data because it examines the effects of policies and community responses on flood risk.

These urban areas in Kenya serve as the main locations for the research specifically because they exist in flood-prone areas due to their geography high population counts and urban development difficulties. Research investigators have selected these urban areas because they deliver essential knowledge for this study.

The research focuses on obtaining data from urban residents alongside urban planner professionals and flood-management officials from non-governmental organisations who operate within specific urban areas.

The study makes use of purposive sampling to determine its data sources. An entire decade of online databases combined with government publications and NGO reports provides time-tested reliability to the underlying data. The selection process relied on the publisher and author reliability guidelines to choose the latest information available for reflecting modern conditions.

The research used primary and secondary data as its primary data collection instruments. Research institutions' government reports and NGO publications combined with academic journals supplied data about population statistics and infrastructure conditions together with policy effects on flood safety methods and local responses. The methodological combination produced a complete understanding of modern yet historical flooding problems in Kenyan urban areas. The current project analysed data in an organised pattern to handle urban flood challenges in a logical framework of causes and vulnerabilities along with management practices.

IV. FINDINGS & DISCUSSION

4.1 Causes and Elements of Urban Flooding in Kenya

4.1.1 Hydrological Factors

Researchers have used hydrological factors in Kenyan urban areas as a fundamental method to evaluate flood risks. The investigation of water flow rates together with surface water runoff river basins and urban drainage networks enables stakeholders to determine flood conditions. The construction activities along with paved areas during urban development cause substantial changes to natural hydrological processes (Howland, 2023). Urbanisation in Nairobi has produced swift changes to land elevation while creating more man-made surfaces that diminish water absorption. The circumstances of informal settlements together with poorer neighbourhoods display intense water accumulation because these areas have extensive sealed ground surfaces during rainy conditions.

Flood dynamics have become more challenging due to human alterations in river basins alongside catchment areas. The Nyando River and Nairobi River serve as the main water sources for the residents who inhabit urban areas across Kenya (Ochieng & Ombok, 2024). River management of excessive rainfall faces difficulties because human-made changes from urban growth including unauthorised home building and construction impair their operations. The urban development process in Nairobi has reduced natural buffer zones by transitioning wetlands and green spaces into settlement areas which causes river overflows during heavy rainfall periods. The scarcity of research models suggests that human modifications to drainage networks result in increased flood frequency together with elevated flood intensity (Rukanga, 2024). The recent overflow of the Nairobi River occurred mainly because informal housing was built too near the riverbanks while multiple sewage outlets dumped effluent into the river leading to bank erosion that resulted in flood bursts. The Mombasa city and lower regions of Nairobi face elevated risks of flooding because of elevated groundwater levels which worsen due to defective drainage systems.

4.1.2 Topology and Natural Drainage

The landscape features of an urban area determine how vulnerable it becomes during flooding situations in Kenyan cities. Three critical elements namely altitude, slope and soil structure establish the boundaries of flood-prone areas. The topographical variation between Eastleigh and South C cities creates a bowl effect because drainage systems fail to contain accumulated water during heavy rainfall according to Olajubu et al. (2021). Environmental development projects situated close to flood plains where rivers flow or lakes exist as demonstrated in Kisumu near Lake Victoria and Nyando River increase hazards during seasonal or flash flood events (Talian et al., 2017). Modern technology using GIS and satellite imagery helps environmental scientists to identify encroachment locations while determining the potential flood exposure areas. Human activities which include deforestation together with urban construction and poor planning practises have destroyed traditional flood protection systems from natural systems such as forests wetlands and slopes therefore escalating flood hazards (Satterthwaite et al., 2007; Awuor et al., 2007).

4.1.3 Natural Causes

Unprecedented patterns of changing weather have become a consequence of Climate Change which creates unpredictable precipitation in Kenyan urban areas. Studies project rainfall will rise by 20% throughout the following fifty years and this increase will directly affect metropolitan areas including Nairobi and Nakuru Mombasa Kisumu and Eldoret (Kotikot et al., 2024). The timing and intensity of both long and short rain seasons are modified by global-scale phenomena including the El-Nino Southern Oscillations (ENSO) together with the Indian Ocean Dipole (IOD) as well as modifications in monsoon winds resulting in changes in sea surface temperatures and atmospheric moisture levels. Higher rainfall events together with immediate flood occurrences result from this effect. The coastal position of Mombasa exposes the city to increased dangers from storm surges alongside high tides because of climate change effects that overwhelm local disaster readiness efforts (Mahongo, 2006; Awuor et al., 2007).

4.1.4 Anthropogenic Causes

The growing population together with rapid urbanisation patterns in Kenyan cities increases flood risks. By 2050 the urban population globally will reach 68% which poses substantial pressure on urban infrastructure especially within informal areas where residents construct their homes from tin materials that fail to resist flooding (UNDESA, 2018). The multiple borehole installations resulting from water scarcity lead to reduced water levels below the surface which results in rain-induced surface water accumulation (Kirui et al., 2021). Flooding gets worse because of weak waste management practises and absent maintenance work on the current drainage infrastructure. The study by Mukui (2019) documented how inadequate waste disposal in Nairobi Mukuru slums blocked drainage channels with diapers and other non-biodegradable waste thus causing extensive flooding. Urban slum residents face extra risk of flooding because their tin houses easily break during storms and the public facilities do not receive proper maintenance nor operational management (Ketter, 2018; Business Daily, 2023).

4.2 Community Flood Risk in Urban Areas Vulnerability Analysis

4.2.1 Systematic Analysis of Vulnerability

The economic gap in Kenyan cities drives up the susceptibility to flooding in urban areas. Economic differences between wealthy and economically disadvantaged people produce differences in living situations together with housing standards and service availability. The specific urban neighbourhoods of Mathare and Mukuru in Nairobi as well as Manyatta in Kisumu show high poverty levels with excessive population density and insufficient infrastructure according to Michel et al. (2018). The inadequate drainage and defective sewage systems in these locations make them highly vulnerable to flooding occurrences. People in working-age groups who live in these settlements find themselves unemployed so they depend on informal jobs until floods destroy their entire economic base. The floods that hit Nairobi in 2024 forced more than 250,000 people from their homes while floodwaters extended through homes for lengthy periods and simultaneously raised health risks while quashing economic activities (African Medical and Research Foundation [AMREF], 2024). Kisumu experienced disruptive floods in 2020 that targeted its fish markets thereby pushing citizens to depend more heavily on charitable donations according to Aura et al. (2020).

4.2.2 Geographical Vulnerability

Urban flood vulnerability heavily depends on geographical elements which affect the area. Massive water bodies surrounding Kisumu and Mombasa make these cities vulnerable to flooding because of storm surges and high tides. Mombasa displayed its exposure to storm surge-driven flooding events during Cyclone Kenneth in 2019 although the cyclone missed the city (Atieno, 2019). The expansion of urban areas across low-lying terrain and adjacent to rivers and lakes significantly raises flood exposure because these waterlogged regions naturally hold excessive rainfall. Excessive runoff caused by land degradation caused by car washing creates risks of mudslides together with landslides according to Howland (2023).

4.2.3 Institutional Vulnerability

Flood vulnerability increases through institutional failures within urban planning fields as well as problems with communication systems and disaster risk management systems. The NDC national climate action plan together with insufficient communication channels fails to reach residents who remain unaware about floods and protection measures (Tobiko et al., 2020). People remain unprepared because of a breakdown between short-term survival priorities and long-term environmental or risk management objectives. Landless status in informal settlements prevents residents from making property or environmental investments according to Dodman et al. (2019). Development activity avoids spaces at risk of flooding thus creating inferior living conditions that strengthen poverty and susceptibility patterns. The institution faces another challenge through deficient disaster preparedness education because this makes most residents remain passive instead of taking proactive roles in flood management activities (GFDRR, World Bank, 2023; Howland, 2023).

4.3 Discussion

The study of urban flooding in Kenya demonstrates multiple factors which enhance communities' risk for flood-related destruction. Research confirms the leading role that hydrological modifications from urban growth play according to this investigation. Kenyan cities are experiencing rapid construction of non-porous building structures and road surfaces that prevent natural water soaking and water drainage systems. The research agrees with Zhang (2013) who explains through the urban metabolism theory that urban expansion leads to unstable resource equilibrium. The pursuit of economic development has generated extensive impermeable installation structures to meet residential and commercial requirements thus fundamentally transforming how water distributes and is managed.

Affluent neighbourhoods in Nairobi, Kisumu and Mombasa receive minimal flood management compared to informal settlements where unmonitored buildings are built beyond safety principles for water movement and waste

functions. The lack of waste and sewage regulation by authorities creates additional flooding and poses health dangers to people due to water pollution of natural bodies. This study confirms previous observations about flooding patterns in African cities alongside other cities from the low and middle-income brackets where unplanned development and inadequate waste disposal cause flooding conditions (Balaaian et al., 2024). The integration of urban development into natural drainage networks in Mumbai alongside Jakarta has caused excessive rainwater overflows (Smith 2023; Bhide 2024).

The unpredictable and forceful nature of climate-induced rain changes pushes urban planners into challenging battles because of their modifications to rainfall patterns. Expanding urban areas by clearing green spaces creates flooding problems because natural soil loses its ability to absorb water. Rising tides along with possible intense and violent weather patterns pose new dangers to Mombasa and other coastal municipalities because these threats threaten to nullify carefully built resilience plans (Bhidhe, 2024).

Kenyan urban communities face high susceptibility to flooding because of numerous socio-economic circumstances which create poverty. The research establishes a strong relationship between poverty-stricken neighbourhoods and increased flood exposure because most slum residents live in poverty (Rentschler et al., 2023). Rapid urban expansion resulting from employment and improved living standards opportunities has produced unmanaged urban expansion which adheres to urban metabolic principles that cause environmental deterioration (Zhang, 2013).

The rapid flow of city dwellers led to the creation of informal communities building their homes in areas prone to flooding since the residences are economically viable. Improper drainage systems throughout these settlements create enhanced susceptibilities towards flooding together with sanitation-related wellness threats. The slum areas of Nairobi experience changes in land utilisation when developers construct high-density inexpensive housing thus disrupting natural drainage systems (UN-Habitat, 2016).

The way environmental risks are allocated shows a clear gap between richer planned areas that benefit from resources that reduce flood risks and the poorer communities that suffer the most according to GFDRR and World Bank (2023). This research demonstrates existing institutional weaknesses because government policies do not efficiently connect to local community initiatives. The practical deployment of Nationally Determined Contributions (NDCs) policies under the Paris Agreement fails to connect with communities effectively because it lacks community involvement in information outreach thus impeding disaster readiness (UN, 2017).

Urban development needs correct planning to unite disaster risk reduction with social and economic growth while recognising both fast urban growth and land use reforms as well as varying impacts across different community types for successful flood prevention.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

While causes of urban flooding in Kenya in known to arise from the hydrological and topographical causes, the natural and man-made events equally contribute. Changes that human beings bring about by the construction of towns and roads which increase the albedo affect natural ways of flood control hence leading to floods as observed in Nairobi city. Housing in low-lying areas without proper drainage systems, proximity to the river in areas such as Eastleigh and South C and informal settlements on edges of river banks and wetland areas contribute to vulnerability to floods. These challenges are topped up by challenges in urban planning and the discharging of wastes which most of the time end up blocking drainage systems making the flooding worse.

Environmental climate changes provoke more urban flooding through unpleasant changes in the rain distribution, and quantity and extreme climate conditions. Mombasa is one of the coastal cities which is often at higher risk from storm surges, especially from rising sea levels. Flood risks are increased by geographical factors such as occupation of land close to water sources and areas of low relief. Lack of capacity in institutions and lack of communication on disaster risks and climate policies expose people to these risks. Furthermore, poverty, majority dwellings in informal settlements and inadequate resources limit the community's ability to enhance facilities or move from risk-prone zones. All these factors put together call for ecological and sustainable urban and rural development, proper drainage systems and disaster management plans.

5.2 Recommendations for Improved Urban Flood Management

Future climate action projects should create spaces that consider urban settlers in both affluent and informal residential areas as stakeholders. This will create platforms for informed decision-making processes with consideration of ideas and contributions from experts and those whom the project would benefit. The participation will also benefit from locally affordable experts, encouraging representation and preventing investment from external involvement, which may be expensive. Presentations from diverse industries will increase attention to climate change, increasing

people's interest in contributing to climate action. This involvement will improve the effectiveness of green infrastructure development. The inclusion will enhance the community's sensitivity and value of the project, enhancing sustainability and practicality.

Moreover, the government should develop better accountability mechanisms free from corruption. Although political and power dynamics influence the practicality of the programs, the government should set a positive example of the effectiveness of accountability structures, demonstrating the effectiveness of disaster management offices at the county level. This mechanism will enhance people's trust in the government, creating possibilities for better governance. The government should also call for local, national, regional, and international cooperation. A unified front will enhance the effectiveness of the program, informed by quality, correct information from the local community. This element calls for partnership and cooperation from the government, non-government, and international organizations.

REFERENCES

African Aid. (2006). *Poor people's experiences with urban flooding in African cities.* African Aid.

Aura, C. M., Nyamweya, C. S., Odoli, C. O., Owiti, H., Njiru, J. M., Otuo, P. W., & Malala, J. (2020). Consequences of calamities and their management: The case of COVID-19 pandemic and flooding on inland capture fisheries in Kenya. *Journal of Great Lakes Research, 46*(6), 1767-1775. https://doi.org/10.1016/j.jglr.2020.09.007

Awuor, C. B., Orindi, V. A., & Adwerah, A. (2007). *Climate change and coastal cities: The case of Mombasa, Kenya.* Rockefeller Foundation.

Baddianaah, I. (2023). We all share the blame: Analyzing the root causes of flooding in African cities with specific reference to Harper City, Liberia. *Environmental Challenges, 13*, 100790. https://doi.org/10.1016/j.envc.2023.100790

Balaian, O., Darabkhani, H., & Zare, S. (2024). Urban development and flooding: The impact of unsustainable growth on flood risks. *Journal of Urban Planning and Management, 40*(3), 345-360.

Business Daily. (2023, December 23). Shoddy Nairobi buildings at high earthquake risk. *Business Daily.* https://www.businessdailyafrica.com/bd/economy/shoddy-nairobi-buildings-at-high-earthquake-risk-2073900

Desouza, K. C., & Flanery, T. H. (2013). Designing, planning, and managing resilient cities: A conceptual framework. *Cities, 35*, 89-99. https://doi.org/10.1016/j.cities.2013.06.003

Dodman, D., Archer, D., Mayr, M., & Engindeniz, E. (2019). *Addressing the most vulnerable first: Pro-poor climate action in informal settlements.* UN-HABITAT. https://unhabitat.org/sites/default/files/download-manager-files

Dodman, D., Leck, H., Rusca, M., & Colenbrander, S. (2017). African urbanisation and urbanism: Implications for risk accumulation and reduction. *International Journal of Disaster Risk Reduction, 26*, 7-15. https://doi.org/10.1016/j.ijdrr.2017.06.029

Douglas, I., Alam, K., Maghenda, M., McDonnell, Y., McLean, L., & Campbell, J. (2008). Unjust waters: Climate change, flooding and the urban poor in Africa. *Environment and Urbanization, 20*(1), 187-205. https://doi.org/10.1177/0956247808089156

Esperancinha, S. (2022). A new perspective on urban flood risk management: A Nairobi case study. *Tomorrow's Cities, Urban Risk in Transition.* https://tomorrowscities.org/news/a-new-perspective-on-urban-flood-risk-management-a-nairobi-case-study

Flower, B., Fortnam, M., Kol, L., Sasin, P., & Wood, R. G. (2018). Using participatory methods to uncover interacting urban risks: A case study of three informal settlements in Phnom Penh, Cambodia. *Environment and Urbanization, 30*, 301–316. https://doi.org/10.1177/0956247817735481

GFDRR, World Bank. (2023). *Annual report 23: Bringing resilience to scale.* World Bank Group. http://documents.worldbank.org/curated/en/

Gichuhi, J. K. (2010). *Involvement, opportunities and challenges facing disaster response organizations in Kenya: A case study of the Kenya Red Cross Society* (Doctoral dissertation, University of Nairobi, Kenya).

Government of Kenya. (2016). *National housing policy, Kenya.* Sessional Paper No. 3.

Government of Kenya. (2018). *National Climate Change Action Plan 2018-2022.* Ministry of Environment and Forestry, Nairobi.

Hallegatte, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. *Nature Climate Change, 3*(9), 802-806.

Howland, O. (2023). A tale of two rivers: Development, destruction, and despair in Ongata Rongai, Kenya. *Frontiers in Public Health, 11*, 1164881. https://doi.org/10.3389/fpubh.2023.1164881

Jiricka-Pürrer, A., & Wachter, T. (2019). Coping with climate change-related conflicts–The first framework to identify and tackle these emerging topics. *Environmental Impact Assessment Review, 79*, 106308.

Ketter, K. G. (2018). *Managing flooding in residential areas of Nairobi: A case study of South C* (Doctoral dissertation, University of Nairobi). http://erepository.uonbi.ac.ke/bitstream/handle/

Kirui, P., Oiro, S., Waithaka, H., Odera, P., Riedel, B., & Gerke, M. (2021). Detection, characterization, and analysis of land subsidence in Nairobi using InSAR. *Natural Hazards, 113*, 213–236. https://doi.org/10.1007/s11069-022-05296-w

Kotikot, S. M., Smithwick, E. A., & Greatrex, H. (2024). Observations of enhanced rainfall variability in Kenya, East Africa. *Scientific Reports, 14*(1), 12915.

Kryspin-Watson, J., Takemoto, S., Stanton-Geddes, Z., Endo, K., & Takamatsu, M. (2020). *Designing and implementing urban flood risk management investments.* World Bank. https://documents1.worldbank.org/curated/en/

Lambert, V. A., & Lambert, C. E. (2012). Qualitative descriptive research: An acceptable design. *Pacific Rim International Journal of Nursing Research, 16*, 255-256.

Mannan, M., Alam, M., & Haque, A. (2021). The Sendai Framework for Disaster Risk Reduction 2015-2030: A review of its implementation and effectiveness. *International Journal of Disaster Risk Reduction, 58*, 102222.

Mukui, N. W. (2015). *Mass balance of plastics: a case study for Nairobi city* (Doctoral dissertation, University of Nairobi).

Mulligan, J., Harper, J., Kipkemboi, P., Ngobi, B., & Collins, A. (2016). Community-responsive adaptation to flooding in Kibera, Kenya. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability, 170*(5), 268-280.

Onyango, S., Wanjohi-Opil, H. N., Shirley, R., & Mungai, O. (2024, July 9). Rebuilding Kenya stronger: Here's what's needed to rebound after catastrophic floods. *World Resources Institute.* https://www.wri.org/insights/rebuilding-kenya-stronger-after-catastrophic-floods

Oyvat, C., & Gĩthĩnji, M. (2019). Migration in Kenya: Beyond Harris-Todaro. *Greenwich Papers in Political Economy, 27168.*

Pelling, M., & Wisner, B. (2012). *Disaster risk reduction: Cases from urban Africa*. Routledge.

Ricardo, D. R. C. (2019). *Donors' impact on the work of development implementing organizations*.

Satterthwaite, D., Huq, S., Pelling, M., Reid, H., & Lankao, P. R. (2007). Understanding vulnerabilities of cities and the urban poor to climate variability and change. In *Adapting to climate change in urban areas: The possibilities and constraints in low- and middle-income nations* (pp. 15–50). International Institute for Environment and Development. https://www.jstor.org/stable/resrep01252.7

Smith, K. (2024). *Flood mapping explained: What is flood mapping and how do you use it?* https://www.royalhaskoningdhv.com/

Staddon, C., Ward, S., De Vito, L., Zuniga-Teran, A., Gerlak, A. K., Schoeman, Y., ... & Booth, G. (2018). Contributions of green infrastructure to enhancing urban resilience. *Environment Systems and Decisions, 38*, 330-338.

Zhang, Y. (2013). Urban metabolism: A review of research methodologies. *Environmental Pollution, 178*, 463-473. https://doi.org/10.1016/j.envpol.2013.03.052