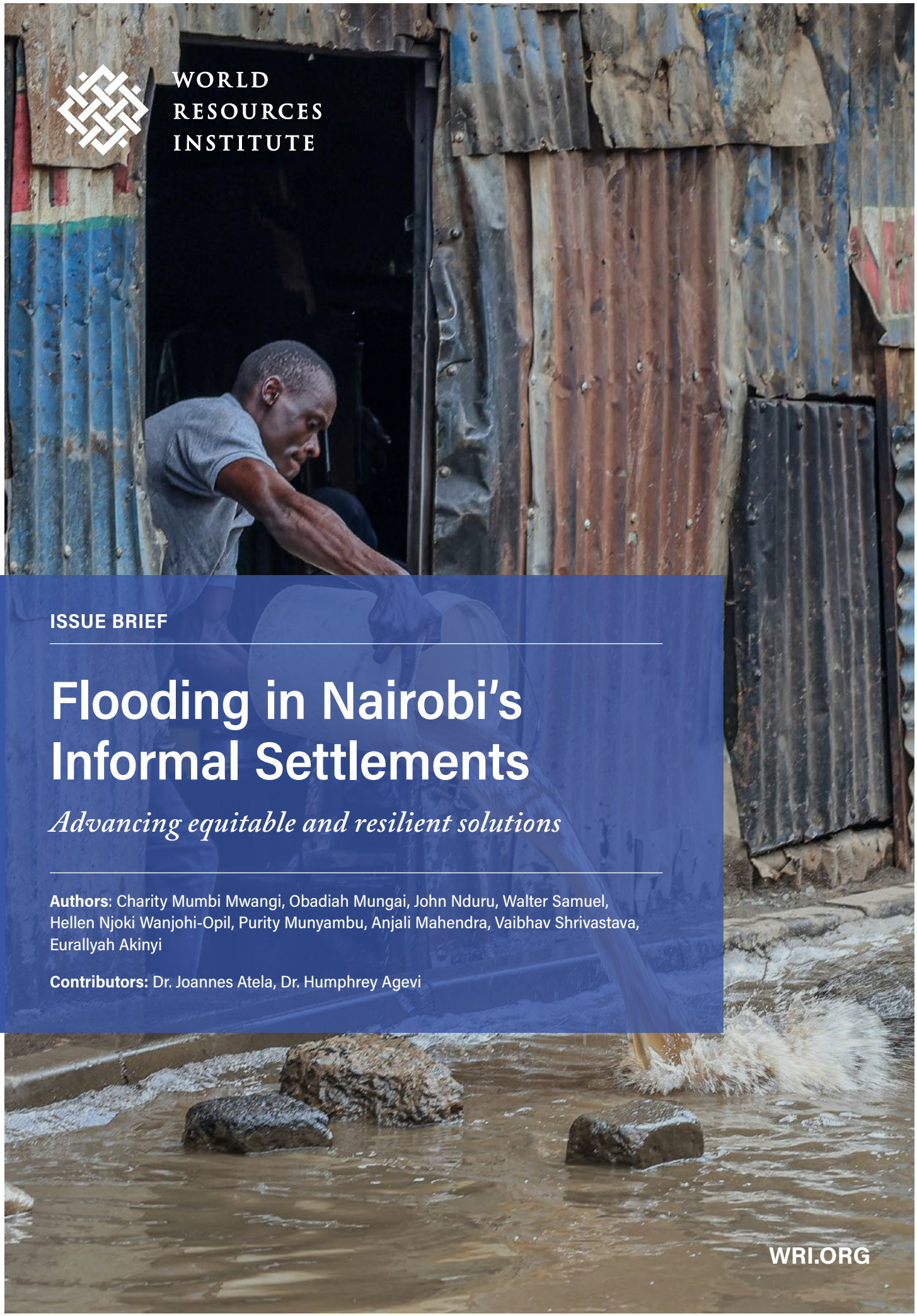

WORLD RESOURCES INSTITUTE

ISSUE BRIEF

Flooding in Nairobi's Informal Settlements

Advancing equitable and resilient solutions

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CONTENTS

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HIGHLIGHTS

- Flooding driven by extreme rainfall is a major and growing climate risk in Nairobi. In 2024, flooding from spring rains, which was 60 percent above seasonal averages, killed 11 people and displaced over 20,000 families; in March of 2026, flooding contributed to 37 fatalities and caused major socioeconomic disruption.
- Floods have destroyed roads and bridges; disrupted livelihoods, education, healthcare, and food systems; heightened gender inequalities and safety risks for women, children, and persons with disabilities; and inflicted disproportionate harm on informal settlements which often lie in floodplains.
- This issue brief assesses the causes and impacts of flooding in Nairobi and the factors that hinder recovery. It combines literature and policy review, geospatial analysis, a two-dimensional hydrodynamic flood model, and exploratory surveys with 98 households.
- It finds that flood risks are amplified by unplanned growth in floodplains and riparian corridors, degraded natural buffers, inadequate drainage, and weak enforcement of planning and environmental regulations.
- It recommends enforcing flood-resilient land-use and riverbank protection, scaling green–grey infrastructure and nature-based solutions, strengthening early warning and anticipatory action (including cash transfers and safe shelters), as well as financing local resilience through mechanisms such as Financing Locally-Led Climate Action (FLLoCA) and a transparent Urban Resilience Fund.

Executive summary

Introduction and context

Nairobi's vulnerability to flooding reveals a critical disconnect between the city's rapid urbanisation and its climate resilience frameworks, necessitating a fundamental shift in disaster risk management (DRM). In 2024, flooding during the months of March, April, and May (MAM) brought 400–660 millimetres (mm) of rainfall (more than 200 mm above the 310 mm seasonal average) resulting in at least 11 deaths, the displacement of 20,968 families, and damage to over 90 kilometres (km) of roads and nine bridges. The MAM 2024 floods were part of a broader national disaster in Kenya, primarily driven by heavy rainfall linked to the El Niño climate cycle (Kenya Meteorological Department (KMD) 2024). The rainfall received during this period was the heaviest in Nairobi city for the past two decades. The scale of these losses is particularly striking, as it demonstrates that even "predictable" climate cycles such as El Niño and torrential rainfall now exceed the city's capacity to cope.

Between March 6 and 22, 2026, flooding contributed to 37 fatalities in Nairobi and caused significant socioeconomic disruption. Informal settlements bore the disproportionate brunt of the disaster due to systemic underinvestment and high-risk geographical locations, including floodplains. Nonetheless, the March 2026 flooding event illustrated that flood impacts now extend beyond peripheral informal settlements into central and formal neighbourhoods. Nairobi's unchecked urban growth into flood-prone areas, compounded by underinvestment in drainage facilities, is colliding with more extreme weather, exceeding the city's limited storm water infrastructural capacity and social safety nets.

Nairobi's struggle with flooding is not a modern anomaly, but a recurring historical challenge that has intensified alongside the city's rapid, often unplanned, westward-to-eastward expansion, increasingly into flood-prone areas and floodplains. Since the devastating floods of 1961 and the 1997/98 El Niño, the city has repeatedly seen its drainage infrastructure overwhelmed, followed by intense flooding. This occurred 19 times, with the most severe consequences in 2006, 2012, 2018, and most recently in 2024 (Kilavi et al. 2018). However, the MAM 2024 season marked a turning point where seasonal precipitation was nearly double the seasonal average (Mogaka et al. 2006).

The scale of death and destruction exposes the high cost of inaction, and points to the urgent need for different policy choices, and better implementation of laws such as the National Disaster Risk Management Act (2023). It also highlights critical knowledge gaps regarding the localised infrastructural, socioeconomic, gendered, and often "invisible" impacts of flooding in informal settlements. Addressing these gaps is essential to informing strategies that strengthen urban resilience and support more equitable adaptation efforts.

This issue brief provides and evaluates factors that intersect to create flood risks in Nairobi, the resultant impacts, and provides recommendations necessary for evidence informed decision-making. It analyses the factors that exacerbated death and destruction caused by the torrential rains of 2024 and 2026. It highlights the fact that current "reactive" strategies and uncoordinated institutional responses are no longer sufficient, and sets the scene for a transition from exclusionary, reactive enforcement to inclusive, rights-based urban resilience. This is increasingly evident in a city where severe floods historically expected to occur only once every 50 years can now strike multiple times within a single decade (KMD 2024; Etyang 2026). It also provides a roadmap for safeguarding Nairobi's most vulnerable populations.

About this issue brief

This publication investigates Nairobi's 2024 floods and how systemic drivers intersect to create high-risk flood zones within the city's informal settlements. These drivers include the city's topography and hydrology, encroachment on riparian corridors, inadequate drainage infrastructure, and weak land-use enforcement. The 2024 MAM floods were selected as the primary lens for this analysis because they were the most severe flooding episode in Nairobi in two decades (KMD 2024) and thus provide the richest evidence base for identifying which structural and governance failures amplify the destructive impact of extreme rainfall. While broad climate data for the city exists, this brief investigates the granular infrastructural, socioeconomic, and policy tipping points that cause a seasonal rainfall event to result in loss of lives, displacement of residents, and the destruction of critical community assets (World Resources Institute (WRI) 2024).

The intended audience includes those who require evidence-based justification for risk-informed budgeting. They comprise decision makers within the national and county government agencies (such as the Nairobi City County Government (NCCG), the Nairobi Rivers Commission (NRC), and sectoral ministries), development partners, civil society organisations (CSOs), academia, community-based organisations (CBOs), and

private sector actors. The analysis is designed to support decisions related to climate-resilient land-use planning and enforcement, prioritisation of green-grey infrastructure investments, and the strengthening of early warning systems, anticipatory action, inter-agency coordination, and disaster risk response systems. It also informs the design of inclusive, community-centred resilience interventions. By linking evidence on flood drivers and impacts to actionable recommendations, the brief aims to guide more coordinated, risk-informed, and forward-looking approaches to both flood preparedness and response in Nairobi.

Approach and methodology

This issue brief was developed using a robust, mixed-methods research framework led by WRI, with support from the African Research and Impact Network (ARIN), and the communities. To capture a comprehensive picture of the MAM 2024 floods, the research team conducted spatial mapping of flood-prone hotspots, the city's topography, land-use changes and biodiversity loss over time; analysed historical hydrometeorological data from KMD and facilitated household interviews and community dialogues with affected residents in informal settlements. The researchers prioritised a bottom-up, community-led data collection process to document the "invisible" and often undocumented socioeconomic impacts such as the increase in gender-based violence and mental health trauma that are frequently excluded from top-down assessments. This collaborative approach ensured that the findings were grounded in the lived realities of those most affected by flooding extremes.

While providing detailed localised insights, this research acknowledges key limitations in the quantification of property loss, spatial projections of anticipated future flooding impacts, and the long-term health trajectories of displaced populations. Due to the informal nature of many affected businesses and settlements, the exact monetary value of destroyed assets remains unquantified, and our assessment primarily focuses on immediate post-disaster impacts rather than decadal longitudinal trends. Additionally, while we identify systemic drivers of flood risk, the research did not include a full engineering feasibility study for specific infrastructural shortcomings and quantifiable deficits, for example, city drainages. Despite these constraints, the brief offers critical evidence base for urban planners and resilience practitioners to design interventions that are both technically sound and socially equitable.

Key findings: drivers and environmental, socioeconomic, and governance impacts of flooding

Nairobi's flood risk is heavily shaped by physical geography, hydrology, and urban soil characteristics that create a structural predisposition to flooding. The city slopes down from west to east, from 1,800 to 1,600 metres (m) above sea level, naturally funnelling runoff from the western uplands into lower-lying eastern floodplains where most of the informal settlements are situated (Mogaka et al. 2006; NCCG 2020). This natural vulnerability is exacerbated by the city's dominant volcanic soils, Mollic Nitisols, which exhibit moderate to low permeability. When compacted by rapid urbanisation, these soils lose their ability to absorb water, dramatically increasing surface runoff (Onyancha et al. 2011). Furthermore, the Nairobi, Ngong, and Mathare rivers traverse these densely populated settlements, turning them into high-velocity flood corridors during extreme precipitation events (Davies 2024).

Unplanned urbanisation and poor land-use management have fundamentally compromised natural flood buffers and existing drainage systems. Rapid urbanisation has led to the loss of wetlands and natural buffers, while informal settlements frequently encroach on fragile riparian lands (Onyancha et al. 2025; *Kenya Institute for Public Policy Research and Analysis* (KIPPRA) 2024). This pressure is compounded by poor solid waste management that clogs existing drainage networks and the loss of urban green spaces that once absorbed excess water, significantly intensifying the risk of flash floods (Onyancha et al. 2011). Satellite imagery analysis confirms that Nairobi's impervious surface cover has expanded significantly in the past two decades, directly correlating with increased flood extents during comparable rainfall events. The NRC, whose core mandate is to oversee and coordinate the restoration and sustainable management of the city's river basins, is currently restoring a 27.6 km section of Nairobi River. The initiative combines sewer and drainage infrastructure, river dredging, channel expansion and re-meandering, river cleanups, and ecosystem restoration works to reduce flood risk while creating green livelihood opportunities for communities living along the river corridor (NRC 2024).

The floods of 2024 disproportionately devastated the urban poor, triggering severe human health crises and revealing significant, often underreported social impacts. Outbreaks of waterborne diseases including cholera, diarrhoea, and typhoid affected approximately 147,061 people. Floodwaters destroyed homes, small businesses, community infrastructure, and essential sanitation facilities. Much of the damaged infrastructure has yet to

be repaired (Davies 2024; *Field Epidemiology and Laboratory Training Programme* (FELTP) 2024). Approximately 40,000 families were affected by displacement resulting from flood events and government-led evictions of communities living along river corridors. These communities were compensated Kenya shillings (KSh) 10,000 (US$ 75) per family. However, alternative safe relocation areas were not provided, resulting in significant socio-economic challenges, and temporary discontinuation of education among school-going children (Pashayan and Kenechukwu 2025). Beyond these visible impacts, the research found a marked decline in mental health and an increase in intimate partner and sexual violence during the chaos of displacement. We found that relief efforts often failed to account for the specific needs of vulnerable groups including women, children, the elderly, and persons with disabilities. Access to essential social services was often disrupted during the peak of the crisis. Additionally, findings indicate that the absence of anticipatory mechanisms, specifically pre-positioned resources and advance financing for vulnerable households, worsened the scale of losses (Davies 2024). This evidence confirms that flooding in Nairobi is simultaneously a public health, social protection, and engineering challenge.

Institutional responses remain fragmented and under-resourced, with robust policy frameworks undermined by weak enforcement capacity and limited inter-agency coordination. While Nairobi possesses robust frameworks such as the Physical and Land Use Planning Act (2019), the Climate Action Plan (2020–2050) and the National Disaster Risk Management Act (2023) among others, implementation is frequently slowed by low financing, limited inter-agency coordination and fragmented governance. An example of this limited inter-agency coordination was the mandatory enforcement of the 30-metre riparian setback, which displaced over 40,000 residents and destroyed community-managed water and sanitation assets without providing safe alternatives (WRI 2024; Republic of Kenya 2023). While this intervention sought to restore riparian buffers and reduce flood risk, the lack of coordinated cross-sectoral planning—particularly housing, water and sanitation, as well as social protection—resulted in unintended socioeconomic impacts. It also left many reclaimed areas without clear redevelopment or management plans, increasing their vulnerability to re-encroachment and cyclical displacement.

Furthermore, the integration of Disaster Risk Reduction (DRR) into spatial planning remains weak, as climate-resilient interventions such as nature-based solutions (NbS), although provided for in DRR strategies, have not yet been systematically incorporated into urban development processes. Additionally, even though the National Disaster Risk Management Act of 2023 makes provision for ward- and community-led DRR committees, while the Climate Change Act makes provision for ward climate change planning committees, these have not been effectively formed and operationalised, hindering effective community-led early warning systems, and ecosystems restoration resilient to withstand the increasing torrential rainfall and flooding events (Akampurira 2024). This provides a strategic opportunity for the city to reclaim ecologically sensitive areas while advancing more inclusive and rights-based approaches to urban resilience (United Nations Children's Fund (UNICEF) 2022).

Conclusion and recommendations: towards proactive and inclusive resilience

The recurrence of extreme flooding and loss of life and infrastructure in Nairobi demonstrate that the city's current DRM model is fundamentally ill-equipped for a changing climate. Our analysis concludes that the catastrophic impacts of the 2024 and recent 2026 floods were not merely natural disasters but were significantly amplified by systemic failures. These included inadequate drainage infrastructure, the proliferation of impervious surfaces, environmental degradation, settlement expansion into high-risk riparian zones, weak coordination, and ineffective land-use planning enforcement. With the KMD projecting increasingly intense rainfall seasons, the city must urgently address the drivers of intense flooding to prevent further unquantified destruction of property and loss of life (KMD 2026; Mackintosh 2026).

To save lives and reduce human suffering it is crucial to address the disproportionate vulnerability of informal settlements. The research revealed multiple dimensions of harm, indicating that flooding interventions were reactive and did not fully account for the social needs of the affected communities. In particular, the lack of gender equality and social inclusion (GESI)-appropriate rescue centres contributed to surges in sexual violence and psychological trauma. This, compounded by the government's displacements, led to loss of livelihood opportunities, impaired community identity and human dignity, and loss of spaces that people identified historically as "home". Despite such measures, affected households were not provided with alternative relocation areas. To safeguard the 60 percent of the population living in informal settlements, the city must move beyond reactive and potentially harmful enforcement measures such as uncoordinated riparian clearance, toward inclusive, rights-based resilience strategies. These should prioritise the needs of groups that are disproportionately affected including women, children, and persons with disabilities.

Nairobi's resilience depends on a coordinated, multi-actor transition across three strategic phases of disaster management, focusing on both structural safety and human rights.

- **Pre-Disaster (Risk Reduction and Preparedness):** The NCCG and the Government of Kenya must move beyond fragmented policies to strictly enforce the Physical and Land Use Planning Act of 2019 and the National DRM Act of 2023, addressing the weak enforcement that the research identifies as a primary amplifier of flood damage. We recommend the formal integration of community-led DRR committees with ward climate change planning committees to ensure early warning systems reach the "last mile". Furthermore, the NRC should lead the restoration of ecologically sensitive riparian zones using green-grey infrastructure (GGI) approaches that integrate ecosystem restoration with climate-resilient engineered solutions. This approach offers cost-effective flood mitigation while delivering cobenefits for health, ecosystems, and livelihoods, and should be implemented with meaningful community participation.
- **During Disaster (Inclusive Response):** Disaster management agencies and humanitarian actors must activate anticipatory cash transfers to vulnerable households before flood peaks. Response kits for water, sanitation and hygiene (WASH) and health must be pre-positioned in settlement hotspots, with all evacuation centres strictly adhering to GESI standards to mitigate the risk of gender-based violence. Deploying community focal points for real-time alerts, equipped with real-time hydrometeorological data from KMD, is essential to preventing the high mortality rates witnessed in recent 2026 events.
- **Post-Disaster (Recovery and Resilience-Building):** The NRC and NCCG should prioritise rights-based resettlement for populations in high-risk zones, ensuring that safe, affordable housing alternatives are provided before clearing riparian land. Recovery efforts must include the restoration of community-managed infrastructure such as water points and toilets, which are often destroyed during floods or enforcement actions. Additionally, these recovery efforts should include a "build back better" approach for climate-resilient GGI, ensuring they are designed to withstand 1-in-50-year return period events, while improving the overall quality of life of citizens. Finally, the National Treasury must establish a transparent Urban Resilience Fund, leveraging mechanisms like the Financing Locally-Led Climate Action (FLLoCA) programme, to provide the sustained, multi-year financing necessary for large-scale GGI upgrades.

Introduction

Kenya is experiencing rapid urbanisation, with its urban population growing at an annual rate of 4.3 percent. According to the Kenya Population and Housing Census (2019), the country's population currently stands at 47.6 million, with an urban population of 14.8 million (UN-Habitat 2023). Urbanisation is projected to accelerate further, with the urban population expected to increase from approximately 28 percent of the national population in 2021 to 46.3 percent by 2050 (World Bank 2023). Nairobi, the capital city, is home to approximately 5 million residents and has experienced rapid urbanisation, with an annual growth rate of 4.1 percent (Macrotrends n.d.). Over 60 percent of Nairobi's population lives in informal settlements, a rise from 33 percent four decades ago (Population Matters 2024). Approximately 75 percent of urban growth is absorbed by these areas, which occupy only 6 percent of the city's land, often in ecologically fragile regions (*Kenya Institute for Public Policy Research and Analysis* (KIPPRA) 2024). These settlements face vulnerabilities such as flooding, driven by inadequate drainage, poor housing, and marginalisation of development efforts (Republic of Kenya 2016), jeopardizing communities' resilience and heightening socioeconomic risks.

Nairobi experiences a subtropical highland climate with marked wet and dry seasons leading to frequent storms and flooding (Pahwa Gaffar et al. 2019). The primary rainy seasons occur from March to May and October to December. The long rains are experienced in March, April, May (MAM), with an average rainfall amount of 310 millimetres (mm), while the light rains are experienced in October to December, with an average amount of 200 mm (University of Cape Town 2017).

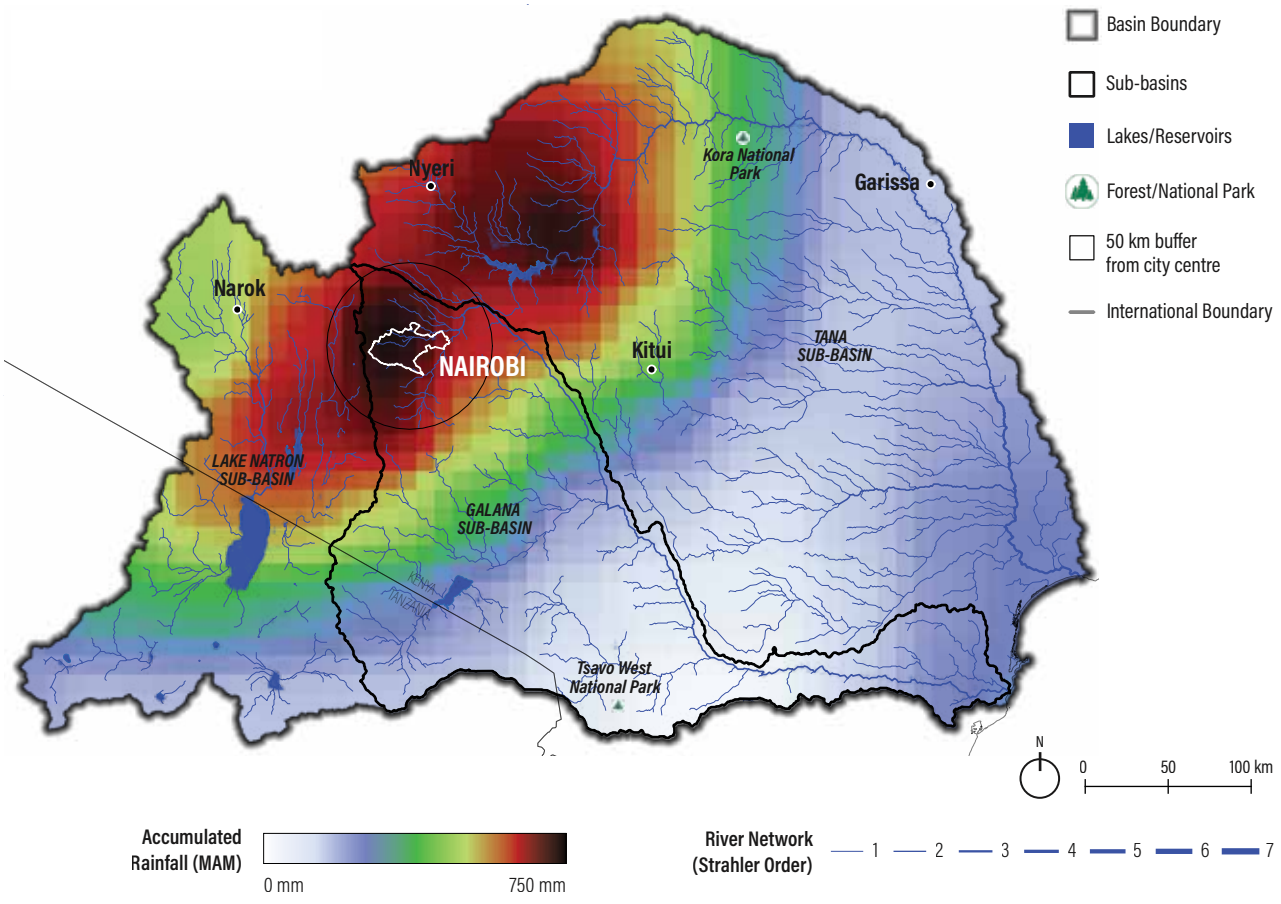
In 2024, torrential rains caused extensive flooding, which overwhelmed existing emergency measures, and exposed structural vulnerabilities embedded in Nairobi's physical geography and urban development patterns. Much of the flooding occurred in historically low lying, flood-prone corridors majorly in the eastern parts of the city, where unplanned and unregulated development has reduced natural flood absorption capacity. In MAM 2024, the average daily rainfall rose to 100–146 mm in March, reaching 400–660 mm in April (Kenya Meteorological Department (KMD) 2024). The intensity of this rainfall is highlighted in Figure 1. The consequences in the flood prone informal settlements were worse and included deaths, property loss, and significant socioeconomic disruption (Davies 2024), alongside impacts in formal areas like Githurai and affluent neighbourhoods like Runda (Mwenesi 2024). The 2024 floods echoed the damage caused by the 1997–98 El Niño, which saw rainfall intensity exceed normal levels by over 100 percent. Despite this precedent, limited and

fragmented adaptation measures left Nairobi's informal settlements largely unprotected, underscoring persistent gaps in anticipatory planning and risk-informed land use (World Bank 2001; The United Nations Development Programme (UNDP) 2002).

More recently, early evidence from 2026 suggests continued risk escalation. On March 6, 2026, Nairobi received approximately 100 mm of rainfall in a single day, as noted by a KMD meteorologist during a focus group discussion (FGD) at the World Resources Institute (WRI). This event significantly disrupted city operations, destroyed property of unquantified value, strained mobility, and resulted in 23 fatalities on that day alone (Mackintosh 2026), rising to 37 fatalities between March 6 and 22, 2026 (Etyang 2026). While earlier interventions, including the 2024 enforcement of a 30-metre (m) riparian buffer by the government may have reduced exposure in some high-risk informal settlement areas, the effects of the floods were still felt across the entire city. Impacts were felt in the central business district (CBD), formal neighbourhoods such as Lang'ata and South C, and informal settlements alike, underscoring the widespread and systemic nature of flood risk. KMD projections further indicated that the MAM 2026 rains would likely be above average, suggesting increasing frequency and intensity of extreme rainfall events.

Flood risk in Nairobi can be understood as the interplay of hazard, exposure, and vulnerability (Nohrstedt et al. 2024). While extreme rainfall events represent the immediate hazard, their impacts are shaped by the city's underlying topography and hydrology. Nairobi's west–east slope, coupled with river systems such as the Nairobi, Ngong and Mathare rivers, channels runoff into low-lying floodplains where many informal settlements are concentrated. Rapid and unplanned development along these riparian corridors has altered natural drainage patterns and reduced the land's absorptive capacity, increasing exposure. Vulnerability is greatest in informal settlements due to limited preparedness, fragile infrastructure, and limited adaptive capacity. Based on this interplay, the issue

Figure 1 | **Accumulated MAM 2024 rainfall in Nairobi County (indicated in the white boundary) and its environs (the larger Nairobi metropolitan area)**



Source: WRI using JAXA GSMap Rainfall; County boundary from Survey of Kenya; FAO Basin Data; FAO Stream Network; JRC Global Surface Water.

brief therefore explores the causes and impacts of flooding in Nairobi's informal settlements, focusing on lessons from the MAM 2024 flooding. It also proposes actionable policy, institutional and operational recommendations to reduce flood risks in Nairobi City with the aim of strengthening coordinated preparedness and response to future flooding.

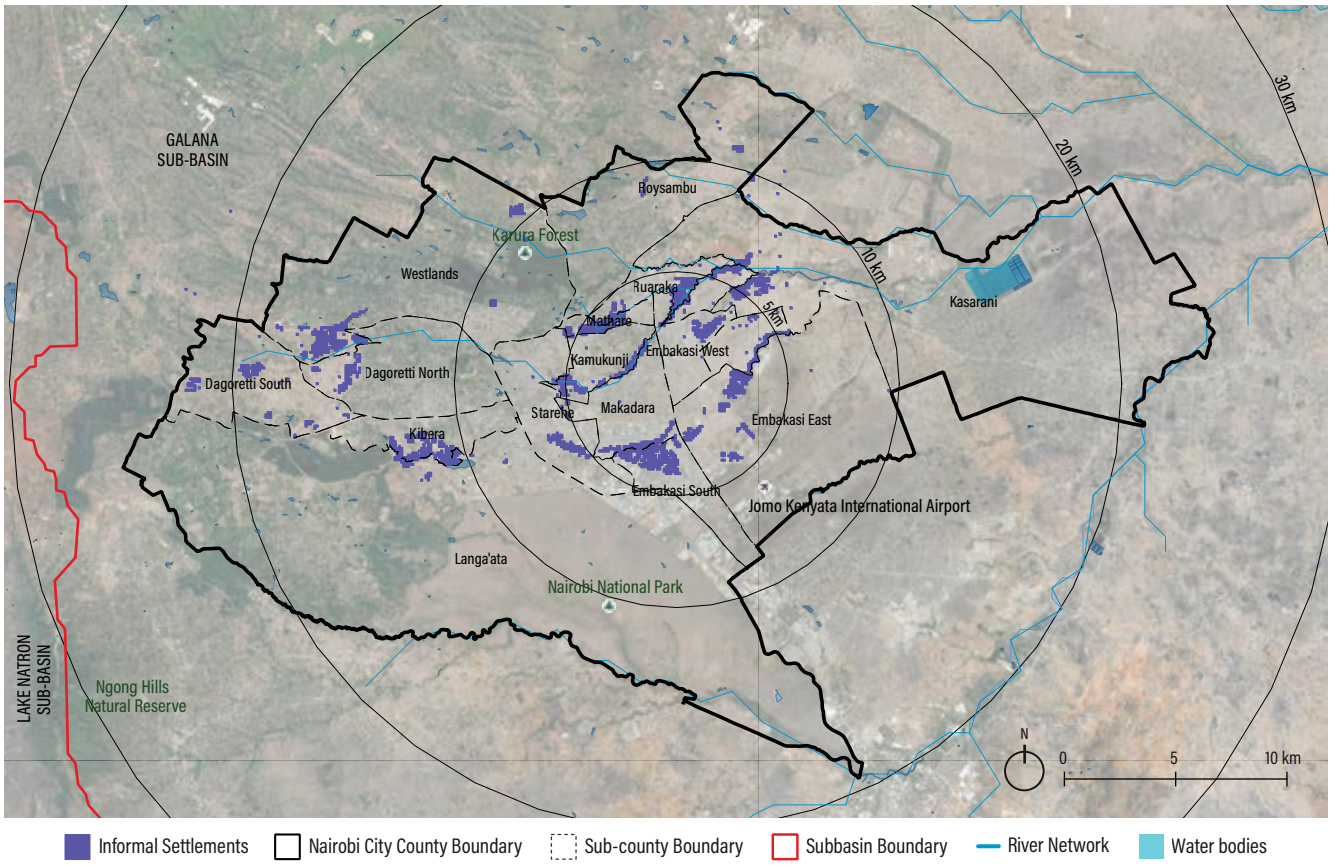
Research questions

1. What factors contribute to repeated flooding events in Nairobi's informal settlements?
2. What are the impacts of the MAM 2024 floods on human health, infrastructure, livelihoods, social-behavioural norms, and ecosystems in Nairobi's informal settlements?
3. What specific policy and action recommendations can promote flooding resilience in Nairobi, including among the vulnerable populations living in informal settlements?

Research scope, approach and methods

This issue brief examines the causes and impacts of flooding in Nairobi, with a focus on informal settlements which often have limited capacity to withstand and recover from climate-related disasters such as floods (Owuor and Mwiturubani 2021). It evaluates the fragmentation in policy, infrastructure, social and institutional responses that exacerbate flood risks[1] and environmental degradation in the city, with insights drawn from the MAM 2024 flooding event. Actionable recommendations are proposed to mitigate flood risks, referencing best practices on gender equity and social inclusion (GESI)-responsive nature-based solutions (NbS), disaster risk policies, climate-resilient city planning, and inclusive disaster response strategies. Given the presence of 200 informal settlements (KIPPRA 2024), as illustrated in Figure 2, the brief aims to deliver cross-cutting flooding assessments and recommendations.

Figure 2 | **Informal settlements in Nairobi City County**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; Building footprints from Google Open Buildings; Extent of Informal Settlements from SLUMAP; Basin polygon and stream network from FAO Basin Data & FAO Stream Network; Presence of water from JRC Global Surface Water; Google Satellite Basemap.

The brief reviews both academic and grey literature to uncover in-depth insights regarding factors that contribute to flooding in Nairobi, utilising secondary sources such as media reports and past journal articles (e.g., Owuor and Mwiturubani 2021). It examines, among others, the historical and changing trends in rainfall, urbanisation, and land use (Shamim 2024).

To evaluate the impacts of the MAM 2024 floods on human health, infrastructure, livelihoods, socio-behavioural norms, and ecosystems in Nairobi's informal settlements, this issue brief draws on secondary literature (Davies 2024; Habtemariam et al. 2021; Owuor and Mwiturubani 2021), government reports, and geospatial data including Digital Elevation Models (DEMs), topography, and hydrology maps. These secondary sources document outcomes such as health risks, infrastructure damage, and policy responses; while exploratory surveys conducted by WRI among 98 households in Kibera, Mukuru Viwandani, and Mathare along the Mathare and Ngong' rivers (July–August 2024) provide insights into lived experiences, coping mechanisms, and perceptions of risk and recovery. Although the survey was not statistically representative of all households in Nairobi, it generated valuable perspectives that complement the secondary data, grounding the analysis in community realities. A sophisticated two-dimensional hydrodynamic model (see Appendix A) simulating the April and May 2024 floods was developed by WRI leveraging open-source geospatial data. This model incorporated topography, land use, and soil absorption capabilities, with rainfall data sourced from the JAXA Realtime Rainfall Watch GSMaP. Simulations tracked maximum flood extent on April 29, 2024, validated through door-to-door surveys to confirm accuracy.

The brief also reviews relevant environmental and urban development policies, identifying specific recommendations to bolster long-term resilience, particularly for vulnerable populations in informal settlements. These policies include the 2018 Thematic Plan for Disaster Risk Management (Republic of Kenya 2018), the Nairobi Climate Action Plan 2020–2050 (Nairobi City County 2020), and the Nairobi Integrated Urban Development Master Plan 2014 (Nairobi City County and the *Japan International Cooperation Agency* (JICA) 2014), among others. The analysis highlights gaps and enforcement issues within existing policies and institutional frameworks that hinder effective Disaster Risk Reduction (DRR) strategies. It then proposes integrated policy and implementation recommendations for mitigating flooding in Nairobi, with a keen focus on informal settlements.

Factors that contribute to recurrent flooding in Nairobi's informal settlements

Based on literature and primary data collected through this study, flooding in Nairobi is caused by a complex interplay of environmental, socioeconomic, and governance factors. Some of the key drivers are discussed below.

Extreme weather events and changing rainfall patterns

Nairobi is increasingly vulnerable to extreme weather events and fluctuating rainfall patterns which threaten infrastructure, public health, and food security. Climate change intensifies droughts and creates unpredictable rainfall seasons, impacting both urban and rural populations and exacerbating poverty among marginalised communities (Howland 2024).

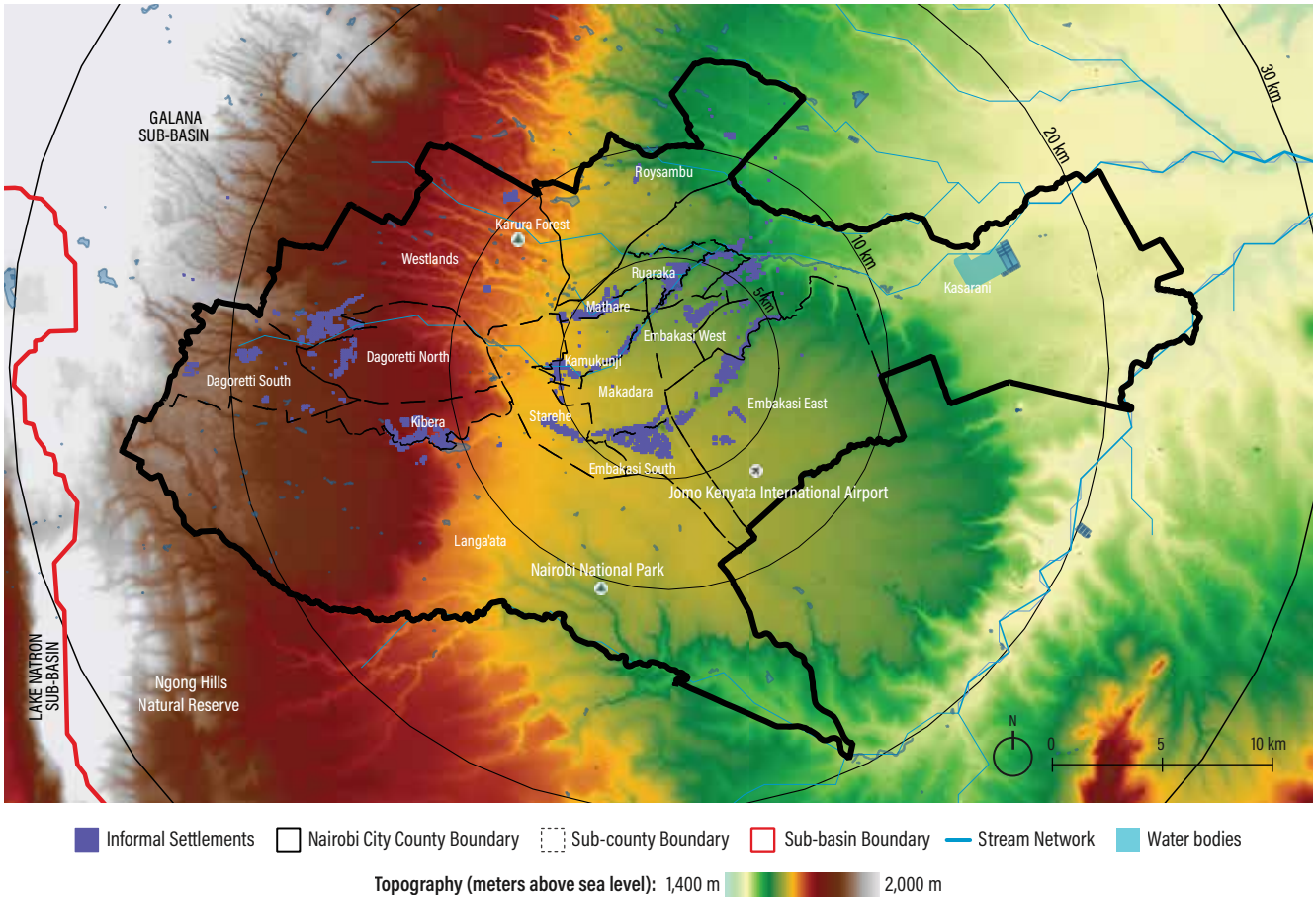
The city typically experiences two primary rainy seasons: long rains from March to May, averaging 310 mm per season, and short rains from October to December, averaging 200 mm per season (University of Cape Town 2017). However, rainfall intensity has risen, with the MAM 2024 season recording 400–660 mm, significantly above the long-term average.

This trend is not new, but it is becoming more severe and occurring more often (Kilavi et al. 2018). Kenya recorded 19 major flood events from 1964 to 2024. The MAM 2024 rainfall was the heaviest recorded in Nairobi for two decades, representing the clearest evidence yet that climate cycles are exceeding the city's adaptive capacity.

Topography and hydrology

Most informal settlements are situated in low-lying areas (eastern parts elevated at 1400–1600 m above sea level as highlighted in Figure 3), floodplains, and river valleys. These areas are inherently prone to water accumulation during heavy rains, flash floods, and river overflows. Due to the increasing built surfaces in the high elevations (western parts at 1900–2000 m above sea level), there has been an increase in surface runoff from these western sections, draining surface water flow into low-lying areas.

Figure 3 | **Topography of Nairobi City County**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; Topography from FABDEM; Informal Settlments data from SLUMAPS; Basin polygon and stream network from FAO Basin Data & FAO Stream Network; Presence of water from JRC Global Surface Water.

Soil characteristics and urban runoff

A clear understanding of Nairobi's soil characteristics is crucial for managing urban runoff and mitigating flood risk. The city's soils are primarily volcanic, mainly Mollic Nitisols, characterised by high clay content, low permeability, and high surface runoff. Their fine texture promotes compaction, reducing water absorption and storage. Rapid decomposition of organic matter due to high temperatures and microbial activity diminishes soil fertility and organic carbon levels, weakening its structure and capacity to retain water. This situation worsens runoff and increases the risk of flooding (Onyancha et al. 2025). As urbanisation expands built-up areas and impervious surfaces, soil integrity further declines, intensifying runoff and flood hazards. Industrial zones like Athi River and Industrial Area exacerbate these issues by preventing water absorption (Toroitich 2008; Geertsma et al. 2009). Research confirms a strong link between the expansion of impervious surfaces and increased flood extents: satellite imagery analysis shows that Nairobi's impervious cover grew significantly between 1985 and 2022, and this expansion correlates with the geographic widening of flood-prone zones during comparable rainfall events (Onyancha et al. 2025; KIPPRA 2024).

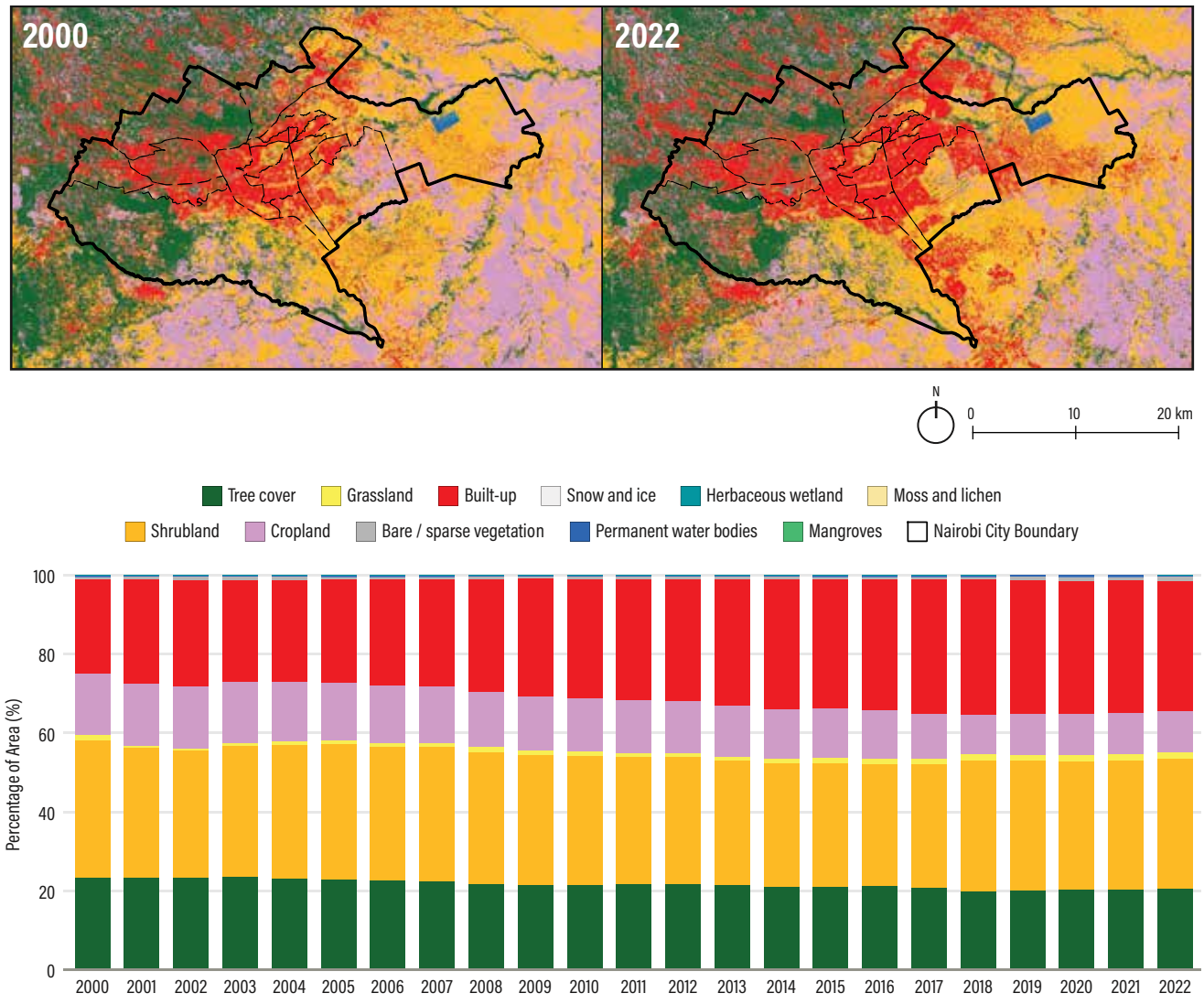
Encroachment on riparian zones and wetlands

The rapid urbanisation of Nairobi has become a critical factor in the degradation of its wetlands, which are vital ecosystems that provide numerous ecological services (Shah and Atisa 2021). Wetlands and riparian corridors act as natural sponges that absorb rainfall, reduce surface runoff, and buffer communities against floods. Their degradation through infilling, pollution, and construction drastically reduces this protective capacity, exposing the city to heightened flood risks. The loss of these ecosystems leads to faster runoff, flash flooding, and declining water quality.

As the city expands, natural areas such as wetlands and forests are increasingly being encroached upon by largely informal residential and commercial developments, resulting in adverse impacts on biodiversity and water quality. Urban areas have expanded at the expense of cultivated and wetland spaces, with built-up areas in some regions increasing significantly from 7.06 percent to 53.61 percent between 1986 and 2018, while agricultural land, including wetlands, plummeted from 86.28 percent to 41.53 percent during the same period (Shah and Atisa 2021). The findings are aligned with spatially generated maps that indicate significant changes in land cover from green spaces to built-up areas between 1985 and 2022 (Figure 4). These land-use changes have been driven by, among other factors, population increase, rapid economic development, and local physiographic features (Oyugi et al. 2017).

Encroachment on riparian lands remains a persistent challenge, significantly increasing flood risk for riverine informal settlement communities. The Government of Kenya, through the Nairobi Rivers Regeneration Project, has begun demarcating and harmonising the city's riparian corridors (Public Notice of Demarcation of Riparian Reserves, 12 December 2025). However, as documented in the strategies section, clearance without coordinated resettlement alternatives has also generated new vulnerabilities.

Figure 4 | **Comparison of land use and land cover change between 2000 and 2022**



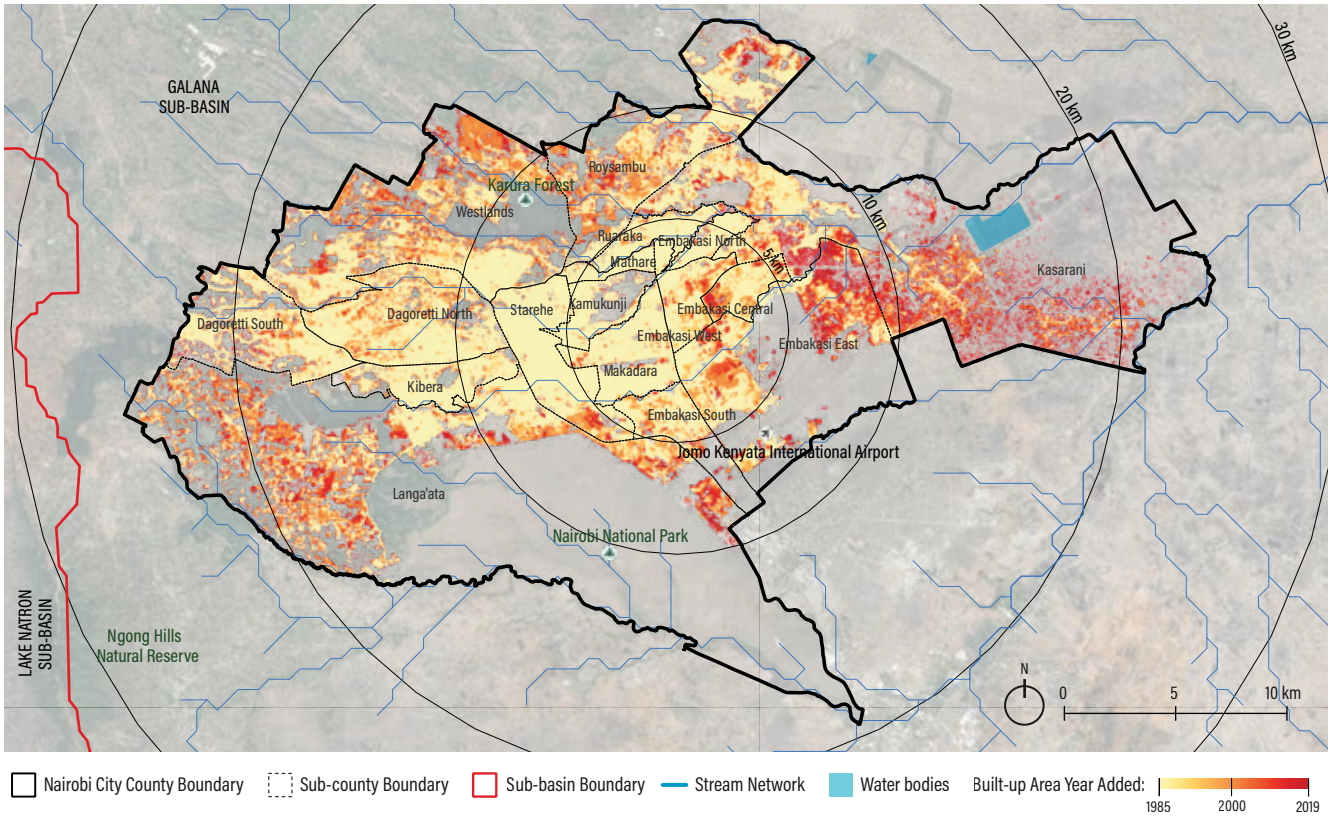
Source: WRI, County boundary from Survey of Kenya; Land use land cover change data obtained from GLC_FCS30D and reclassified to ESA WorldCover land-use classes.
Disclaimer: These maps are for illustrative purposes and do not imply the expression of any opinion on the part of World Resources Institute (WRI), concerning the legal status of any country or territory or concerning the determination of frontiers or boundaries.

Poor drainage infrastructure and system blockages

Nairobi faces significant drainage challenges exacerbated by rapid population growth and insufficient infrastructure. The existing drainage system is often overwhelmed by heavy rains, resulting in frequent flooding and intensified sanitation issues, particularly in slum areas like Kibera and Mathare (Davies 2024). Nairobi's core drainage systems, constructed during the colonial era, have seen little expansion despite rapid urban growth (Connected Places Catapult 2021). The escalation of flood damage over successive events underscores how reliance on these aging systems has left the city increasingly unable to cope: the 1997/98 El Niño brought unprecedented rainfall, resulting in the deaths of over 2,000 people and the displacement of over 70,000 families (Kilavi et al. 2018). In 2018, 573 mm of rainfall during the MAM season displaced more than 332,000 people (Owuor and Mwiturubani 2021). In 2024, the city experienced the heaviest rainfall in two decades with severe consequences for informal settlement residents (KMD 2024; Davies 2024).

The high population density in informal settlements limits the development of effective drainage systems, as closely packed homes leave little room for expansion. Existing drainage planning frameworks such as the Nairobi City Development Control Policy have not been systematically enforced, leading to uncoordinated construction and blocked natural waterways (Juma et al. 2023). Waste management challenges exacerbate the problem; less than half of the city's solid waste is collected, and illegal dumping frequently clogs drains in areas such as Kibera and Mathare (KIPPRA 2024). High-density areas such as Eastleigh, Kilimani, and parts of Westlands have been developed without adequate drainage infrastructure, largely due to the lag in public sector investment (Muchiri and Opiyo 2022; KIPPRA 2024). Figure 5 illustrates the extent of urban grey development in Nairobi City County.

Figure 5 | **Expansion of the built-up area in Nairobi City County**



Note: Here, we illustrate the extent and pattern of Nairobi's built-up area between 1985 and 2019. The map shows that while the city's colonial-era core (developed before 1985) had some drainage infrastructure, most expansion after 2000 occurred in peripheral zones such as Embakasi, Dagoretti, Kasarani, and Lang'ata. These areas have experienced limited investment in drainage systems, leaving them highly exposed to flooding when compared to the older core (Connected Places Catapult 2021; KIPPRA 2024; World Bank 2023).

Source: WRI, County and Sub-county boundaries from Survey of Kenya; Urban expansion data from WSF Evolution 1985–2015 & 2019; Basin polygon and stream network from FAO Basin Data & FAO Stream Network; Presence of water from JRC Global Surface Water; Google Satellite Basemap.

Deforestation and loss of green spaces

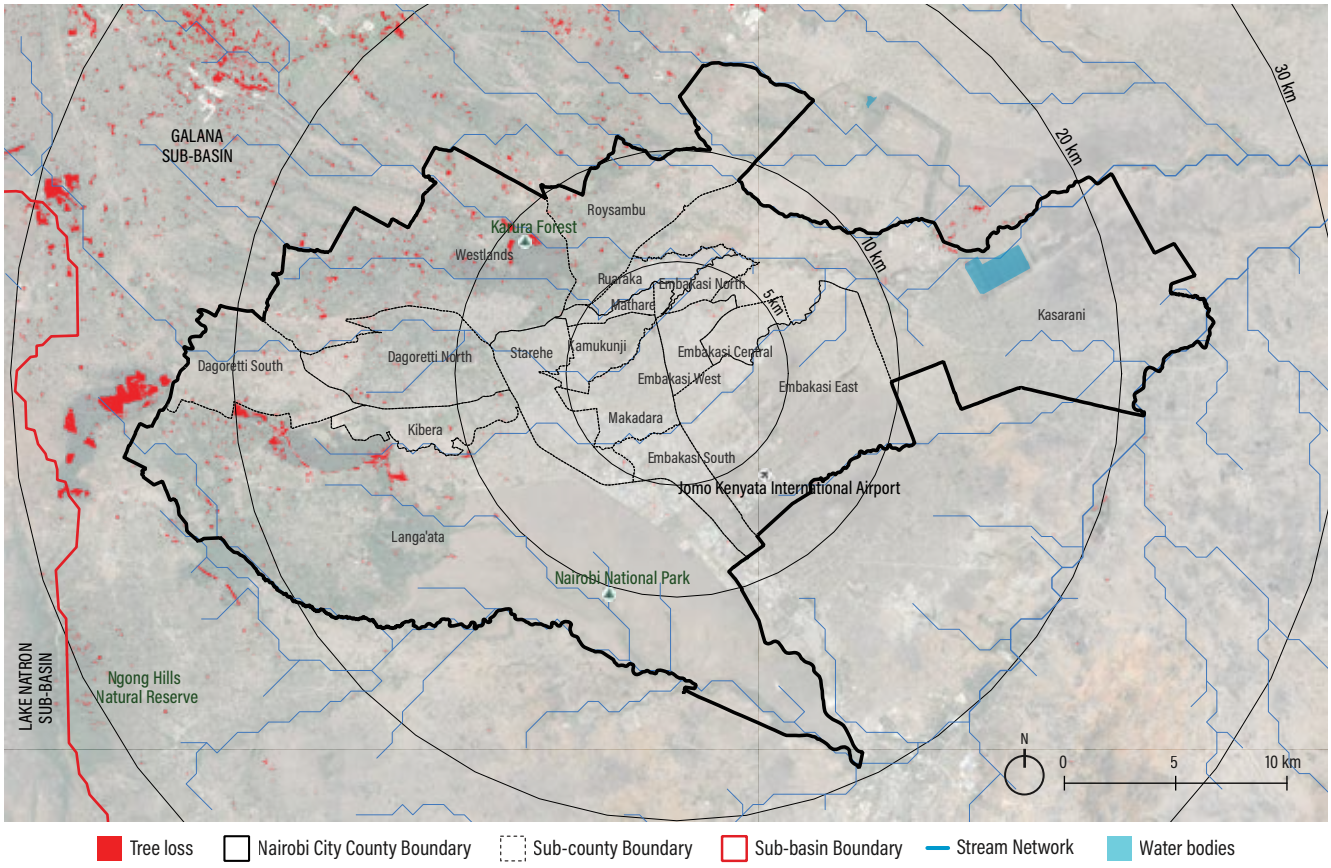
Urban deforestation in Nairobi City has emerged as a critical issue that significantly undermines both environmental integrity and community resilience to climate change. Rapid urbanisation has accelerated the loss of green spaces (Figure 6), reducing the city's capacity to retain water and infiltrate rainfall. Trees play a crucial role in facilitating groundwater recharge and reducing surface runoff, but their removal has led to more intense flooding during heavy rains, soil erosion, and declining water quality (Geertsma et al. 2009). Beyond flooding, the loss of vegetation also heightens Nairobi's vulnerability to climate extremes, exacerbating the urban heat island (UHI) effect particularly in densely built-up areas such as Eastlands (UN-Habitat 2022).

Spatial patterns of deforestation closely align with areas that have experienced recurrent flooding. Comparing green-cover loss maps with flood extents from the 1997/98 El Niño and the MAM 2024 event confirms that as natural vegetation has declined, surface runoff has increased and newly urbanised communities are more exposed to flooding. The loss of riparian and peri-urban vegetation since the late 1990s has reduced the city's natural buffers, expanding the geographic footprint of flood-prone zones (Oloo et al. 2020).

Unplanned and informal settlements

Nairobi is characterised by rapid urbanisation and escalating disaster risks, which disproportionately affect low-income residents of informal settlements. The city's natural morphology, combined with historical patterns of urbanisation, has created a landscape that is highly susceptible to flooding. The city core and its vulnerable informal settlements are located at the base of the Ngong foothills, and the Kikuyu highlands. These areas slope gently through neighbourhoods such as Lang'ata, Kilimani, Kitisuru, Westlands, ultimately channelling runoff into the city core and riverine informal settlements (WRI 2024).

Figure 6 | **Loss of forest and tree cover from 2000 to 2024 in Nairobi City County**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; Tree loss data from Hansen Global Forest Change; Basin polygon and stream network from FAO basin data & fao stream network; presence of water from JRC global surface water; google satellite basemap.

Nairobi's informal settlements occupy just 6 percent of the city's land area (KIPPRA 2024), yet host 60 percent of its population (Population Matters 2024). Moreover, an estimated 75 percent of the city's urban population growth is absorbed within these settlements (UN-Habitat 2006) including areas such as Mukuru (Figure 7). The acute shortage of affordable housing forces many low-income residents into a cycle of vulnerability as they have no option but to settle on disaster-prone land. Unscrupulous private developers and landlords, often referred to as *cartels* due to their role of providing low-cost substandard housing and services in the informal settlements, frequently ignore existing restrictions on building in dangerous locations (Kemwita et al. 2023). In informal settlements, formal drainage infrastructure is often missing, incomplete, poorly maintained, or substandard, causing drainage overflows and flooding (KIPPRA 2024).

Inequality and poverty

Informal settlements are characterised by inadequate infrastructure and limited access to essential services such as clean water, healthcare, education, and sanitation. Most residents live below the World Bank's poverty line of US$2.15 per day (World Bank 2023), which drives reliance on informal, sub-standard and often hazardous services such as unregulated water supply, waste disposal, and electricity connections. The connection between these informal services and flooding is direct: unauthorised and unregulated waste dumping clogs drainage, causing waterlogging, backflows, and flooding; the waste also seeps into the naked, surface-level water pipes causing pollution and disease outbreaks; and substandard electrical installations heighten electrocution risks among humans and animals during floods (Arimah 2010). Critical factors contributing to this vulnerability include lack of effective governance, insufficient resources, and environmental exposures that disproportionately affect marginalised populations.

Fundamentally, the proliferation of informal settlements reflects a long-standing and widening gap between the demand for affordable housing and the state's capacity

Figure 7 | **A section of Mukuru informal settlement and Ngong River prior to the 2024 MAM rains**

Source: Reproduced from SDI-K Know Your City TV (2024, not published).

to supply it. Kenya requires an estimated 250,000 new housing units annually to keep pace with urban population growth, yet current construction output stands at approximately 50,000 units per year, producing an annual shortfall of around 200,000 units and an accumulated national deficit exceeding 2 million units (World Bank 2017; Kenya Permanent Mission to UN-Habitat n.d.). Critically, 83 percent of formally constructed housing targets middle- and high-income segments, leaving only 2 percent for the lowest-income households who constitute the largest share of demand (Government of Kenya 2019). This mismatch means that for the urban poor, informal settlement is not a preference but the only available option.

Conflicting interests and weak enforcement of land use and zoning laws

The scale of unplanned growth into Nairobi's lowland and riparian areas is substantial and well-documented. Between 1988 and 2010, the city's urban built-up area expanded by 438 percent, while agricultural and riparian vegetation declined by 98 percent over the same period (Oyugi et al. 2017). Satellite-based land cover analysis further shows that built-up areas expanded by approximately 47 km^2 between 1976 and 2000 alone, with this growth concentrated in low-lying eastern floodplains and along the corridors of the Nairobi, Mathare, and Ngong rivers—areas originally designated to remain undeveloped (Mundia and Aniya 2006). The government's own Nairobi Rivers Regeneration Programme has since mapped 37 high-risk flood zones across the city, nearly all clustered where riverbanks have been constrained by informal settlements and concrete development, with evidence indicating that encroachment on riparian reserves and floodplains directly contributed to the scale of flooding in 2024 and again in March 2026 (Streamline Feed n.d.; Koech 2026).

Kenya has a substantial body of law and policy designed to prevent precisely this kind of encroachment, yet the gap between legislation and implementation on the ground remains wide. The Water Act (2016) and the Environmental Management and Coordination Act (EMCA 1999) require the protection of riparian reserves and restrict development within legally prescribed setback zones, which are typically 30 m from the edge of a watercourse.

The Physical and Land Use Planning Act (2019) requires that all development approvals account for flood risk and environmental sensitivity. At the city level, the Nairobi Climate Action Plan 2020–2050 and the Nairobi Integrated Urban Development Master Plan (NIUPLAN) both include explicit provisions for floodplain protection and the enforcement of riparian setbacks. The National Disaster Risk Management (DRM) Act (2023) further obligates both national and county governments to integrate disaster risk reduction into spatial planning (Republic of Kenya 2023). Taken together, these instruments create a comprehensive legal framework, on paper, for preventing the settlement patterns that drive Nairobi's flood exposure.

Yet enforcement of these laws is poor due to structural limitations. Urban development decisions in Nairobi are shaped by multiple, often competing actors including private investors, national planners, county authorities, and global diplomatic interests. This has resulted in fragmented and politically driven development pathways that frequently sideline community voices, particularly those from informal settlements, despite constitutional provisions requiring community participation in planning (National Council for Law Reporting 2010). Research shows that the presence of multiple agencies with overlapping mandates over riparian land—including the National Environment Management Authority (NEMA), the Water Resources Authority (WRA), the Nairobi Rivers Commission (NRC), and the Nairobi City County Government (NCCG)—creates uncertainty over enforcement responsibilities, allowing encroachment to persist largely unchecked across administrative boundaries (Owuor and Mwiturubani 2021; Muketha 2020). A study of Nairobi's riparian zones found that planning and development control mechanisms are weak, land administration guidelines for securing riparian widths are unclear, and biophysical characteristics are rarely factored into development approvals (Muketha 2020). As of March 2024, NIUPLAN and other physical planning regulations remained inadequately enforced, failing to prevent the continued expansion of illegal developments within riparian areas and floodplains. A key structural gap identified in WRI research is the absence of systematic consultation between the Urban Planning Department, which approves construction permits, and the Nairobi City Water and Sewerage Company (NCWSC), which provides water and sewer services. In practice, development approvals are routinely granted without verifying whether the proposed site has adequate drainage or falls within a floodplain. This disconnect results in over-extraction of groundwater and pressure on water and sewer infrastructure in flood-prone zones. Failure to coordinate with WRA has similarly undermined floodplain zoning and protection of riparian corridors, leading to increased impervious surfaces that strip the landscape of its capacity to drain water and recharge aquifers (Habtemariam et al. 2021). The result, across all these overlapping failures, is accelerated risk accumulation: the very laws and plans that exist to contain Nairobi's flood exposure are rendered ineffective by the fragmented institutional landscape in which they operate.

Fragmented governance and weak institutional coordination in flood risk management

As detailed in the preceding section, Kenya has a comprehensive legal framework for flood risk management, but lacks clear integration with urban DRR, especially for informal settlements. Additionally, enforcement failures are not the product of any single agency's neglect; they reflect a structural accountability gap created by the fragmentation of responsibility across multiple institutions with overlapping and sometimes conflicting mandates. For example, in the context of a proposed new development near a watercourse, the NCCG Urban Planning Department issues the building permit; NEMA is mandated under EMCA to conduct environmental impact assessments and enforce riparian setbacks; the WRA oversees floodplain zoning and river corridor protection; the Kenya Urban Roads Authority (KURA) is responsible for ensuring roads and associated drainage are fit-for-purpose; and the NRC is tasked with riparian restoration. No single authority is clearly responsible for verifying that all of these conditions are met before construction proceeds, and none is formally required to notify the others when approving development in a sensitive area. The result is that accountability dissolves between agencies (Mwenda 2026).

The absence of a unified framework linking disaster management, climate adaptation, urban development, and environmental protection lead to redundancy and weak implementation. For example, in March 2026, the government convened an emergency meeting of the Implementation Committee on the Cooperation Agreement between the National Government and NCCG, directing KURA, the Kenya National Highways Authority (KeNHA), the Kenya Rural Roads Authority (KeRRA), NEMA, WRA, and the National Treasury to produce a joint 48-hour flood recovery plan. This coordination mechanism had to be assembled during a crisis precisely because no standing multi-agency framework for flood risk existed prior to the disaster (Muriuki 2026). This reactive posture is itself evidence of the gap: urban planning, environmental management, and road infrastructure are governed by separate ministries, separate county departments, and separate legal mandates, with no integrated accountability structure that would require them to act together before flooding occurs. Socioeconomic needs of marginalised communities are largely overlooked within this fragmented system, fuelling unplanned growth in high-risk areas and deepening vulnerability. Urgent policy realignment and coherent, inclusive enforcement are required.

Financing inefficiencies further exacerbates these challenges. Approximately 80 percent of Kenya's DRR budget goes to emergency response rather than proactive planning. In addition, counties, including Nairobi, left KSh 973 million in emergency funds unused in the fiscal year (FY)2023/24. This reflects both a reactive financing model and institutional bottlenecks that limit the effective deployment of available resources.

Finally, this systemic failure is deepened by the exclusion of lived experience as a core evidence source. Although the Kenya Constitution mandates public participation (National Council for Law Reporting 2010), participatory planning processes remain insufficiently institutionalised. By sidelining community input, authorities miss critical, localised knowledge regarding water flow patterns and safe zones (Box 1). During the MAM 2024 crisis, this disconnect was evident: county authorities focused on emergency works while civil society organisations (CSOs) like the Kenya Red Cross delivered aid with minimal coordination, resulting in duplication of effort. The National Steering Committee on Disaster Response (NSCDR)

Box 1 | The value of lived experience

While top-down data provide meteorological context, community members in informal settlements may possess granular, "lived" data often missed by central decision makers. Incorporating these voices reveals:

1. **Historical water paths:** Residents can identify historical drainage paths that have been blocked by recent developments, which often differ from outdated official maps.
2. **Localised early warning:** Communities often have informal communication networks that move faster than official bureaucratic channels during emergencies.
3. **Social vulnerability mapping:** Local leaders are well positioned to identify those most vulnerable to risk (e.g., households with elderly members) more accurately than general census data.

Integrating these insights shifts residents from being "victims" of floods to active partners in resilience planning.

struggled with unclear roles and slow decision-making largely due to weak local collaboration. Furthermore, DRR systems remain fragmented; the county's Disaster Management and Coordination Sector and the National Disaster Operations Centre (NDOC) operate in silos, with overlapping policies and weak enforcement (Muchiri and Opiyo 2022).

Addressing these interconnected governance, planning, and financing gaps presents a critical opportunity for Nairobi to transition from reactive disaster response to a more coordinated, anticipatory, and inclusive flood risk management system.

Underinvestment in resilient infrastructure and limited integration of NbS in urban planning

Nairobi's flooding challenges are predominantly geographic rather than infrastructural. The concentration of informal settlements in low-lying floodplains and along riparian corridors lies at the heart of these problems. Investing in resilient infrastructure without correcting this land-use misalignment will not fully mitigate mounting risks. Enforcing riparian setbacks, halting encroachment and developing resettlement action plans for households in the highest risk zones must precede infrastructure investment. Failure to invest in resilient infrastructure and community-led NbS compounds the problems created by natural morphology, deficient infrastructure, governance challenges, and unplanned urban expansion.

NbS are interventions that work with, protect, or restore natural systems to address infrastructure challenges. In urban flood management they include constructed wetlands, riparian buffer zones, urban forests, rain gardens, bioswales, permeable pavements, and green corridors. These are not ornamental additions to the city: a robust body of evidence confirms their effectiveness. Research on green infrastructure studies found that bioretention systems and permeable surfaces can reduce stormwater peak flows by 30–94 percent depending on scale and design (Habtemariam et al. 2021; Esraz-Ul-Zannat et al. 2024). Vegetation buffers in riparian zones both reduce flood peaks and diminish the occurrence of extreme urban heat events (Ferreira 2021). Critically, NbS are often more cost-effective over the long run than grey-only solutions: in urban contexts across Africa, evidence shows that integrated green-grey approaches deliver flood mitigation alongside cobenefits for biodiversity, urban cooling, and water quality that grey infrastructure alone cannot produce (Collins et al. 2025). This is precisely the evidence base that makes Nairobi's continued underinvestment in NbS a measurable policy failure rather than simply a missed opportunity.

The city's underinvestment in NbS is documented and quantifiable. Across Sub-Saharan Africa, less than 2 percent of climate finance currently flows to NbS, despite their cost-effectiveness relative to grey alternatives (Food and Land Use Coalition 2022). A 2025 WRI and World Bank report analysing nearly 300 NbS projects across Sub-Saharan Africa found that while NbS investment grew by an average of 15 percent annually between 2012 and 2021, funding remains a fraction of what is required. Relatively few projects have been implemented in cities specifically, despite urban areas facing the highest climate risks (Collins et al. 2025). For Nairobi, the pattern of underinvestment is evident at multiple levels. Kenya's public investment in DRR has historically been skewed towards emergency response rather than prevention. A risk-sensitive budget review found that post-disaster response and relief accounted for a disproportionate share of marked DRR spending, leaving proactive risk reduction, including green infrastructure, chronically underfunded (UN Office for Disaster Risk Reduction (UNDRR) 2018). The Nairobi City County Climate Action Plan 2020–2050 acknowledges the need for NbS but provides no dedicated budget line or implementation mechanism for their systematic adoption (The Global Centre on Adaptation (GCA) 2025). Additionally, NbS has not been formally integrated into the NCCG's planning frameworks, capital budgets, or infrastructure approvals (African Cities Database 2026). The result is that community-led NbS initiatives such as tree planting and drain clearing remain isolated, small-scale, and disconnected from city planning structures, preventing them from reaching the scale at which their flood mitigation benefits become meaningful (GCA 2025).

Policy gaps, limited institutional capacity, and a deeply embedded preference for immediate grey solutions constrain the adoption of NbS at scale. Planners and policymakers have consistently regarded NbS as complementary rather than essential independent systems, a framing that the evidence does not support. A 2025 validation workshop convened by the GCA found that lack of standardised monitoring frameworks for NbS projects makes it difficult to track their success, secure future investment, and make the case to decision makers who default to conventional infrastructure (GCA 2025). Encroachment on the very spaces, wetlands, riparian corridors, green buffers, where NbS would be most effective further limits adoption.

Without stronger national and county policy frameworks that treat NbS as core infrastructure, dedicated budget allocations, and the institutional capacity to develop bankable projects, NbS cannot reach the scale needed to meaningfully reduce Nairobi's flood exposure (WRI Africa 2024). To support the city in bridging this gap,

WRI has developed a Nairobi NbS strategic framework. This toolkit is designed to guide planners, policymakers, and other practitioners in implementing NbS at different scales within the city. It provides practical guidance on financing options for NbS, developing and implementing innovative catalytic projects, and measuring their long-term impact.

Assessing the socioeconomic and environmental impacts of the 2024 MAM floods

The flooding which occurred between March and April 2024 across Nairobi caused widespread devastation, with impacts heaviest in historically flood-prone areas along riparian corridors and low-lying floodplains, where informal settlements such as Mathare, Mukuru, and Kibera are located. While extreme rainfall triggered the hazard, the scale and duration of impacts were shaped by the concentration of vulnerable populations and infrastructure in inherently exposed zones, and by the city's aged, insufficiently maintained drainage and stormwater systems. Impacts on livelihoods caused more than physical destruction; they affected health systems, strained community and social fabric, eroded livelihoods, and disproportionately affected women, children and persons with disabilities, compounding pre-existing vulnerabilities.

Impact on human health

In Nairobi's informal settlements, the flooding had significant public health impacts, contributing to a rise in incidences of waterborne diseases such as typhoid, cholera, and diarrhoea. This resulted from the collapse of sanitation infrastructure, open defecation, and contamination from destroyed pit latrines (Kenya Red Cross 2024; Gichana 2024). Stagnant floodwaters also created breeding grounds for mosquitoes, spreading malaria and dengue fever (KMD 2024). Outbreaks of these diseases further strained medical facilities which were also damaged during the flooding, particularly in areas like Mukuru and Mathare (Kenya Red Cross 2024).

Disruptions to healthcare services had widespread consequences. Pregnant and postpartum women struggled to access maternal care due to facility damage and unusable roads, while persons with disabilities and limited mobility faced navigation challenges, heightening their vulnerability (Kenya Red Cross 2024). During our 2024 interviews, a wheelchair-bound resident of Mathare described how flood conditions severely restricted his mobility. Thick, slippery mud, stagnant water, and a damaged bridge linking parts of the settlement prevented him from crossing the river to access vital services, including healthcare facilities. He also lost his household items to the floods as he was physically unable to move them to safer ground on time.

A key finding is that the absence of pre-positioned WASH supplies and pre-approved anticipatory cash transfer mechanisms meant that vulnerable households had no financial buffer to cover emergency needs such as health services before or during the flood peak. Without emergency cash, guardians and caregivers could not afford to buy basic necessities like clean water for consumption, energy source for boiling contaminated water, or even soap for handwashing, as local kiosks were either washed away or increased prices due to scarcity. This forced households to consume whatever water was available, often tainted by overflowing pit latrines and flood water mixed with open sewerage. The result was a rapid surge in typhoid and cholera (Kwao 2024). Relief distribution efforts often relied on centralised "collection points" that inadvertently excluded the very groups they were meant to serve. WRI interviews revealed that women with infants, the elderly, and persons with disabilities were often physically unable to compete for relief at crowded distribution lines. Many were unable to move to centralised collection points due to stagnant water and slippery conditions, as well as mobility limitations. This forced the vulnerable population segment to rely on the dwindling resources of neighbours who were equally affected (WRI 2024; *Field Epidemiology and Laboratory Training Programme* (FELTP) 2024; Kenya Red Cross 2024).

Field visit observations revealed that blocked natural drainage paths caused floodwater to stagnate, mixing with unmanaged solid waste and open sewage, creating unhygienic conditions. Even as the water receded, waste and sludge remained, posing long-term health and sanitation issues and increasing the risk of disease outbreaks, particularly for those with limited access to healthcare.

Impact on infrastructure

The flooding in Nairobi (Figure 8) caused severe damage to essential physical infrastructure such as housing, roads, bridges, and water supply networks, much of which has yet to be adequately repaired in the aftermath. These impacts highlight a dual dimension of the crisis: existing infrastructure is either not designed or provisioned to deal with flooding in the current context, or there is simply a lack of appropriate infrastructure altogether. The city's drainage systems are overwhelmed, with only 20 percent of urban residents accessing proper sewerage (Meeuwissen 2022), leaving the existing network grossly overburdened, particularly in informal settlements where makeshift or substandard materials are common (FELTP 2024).

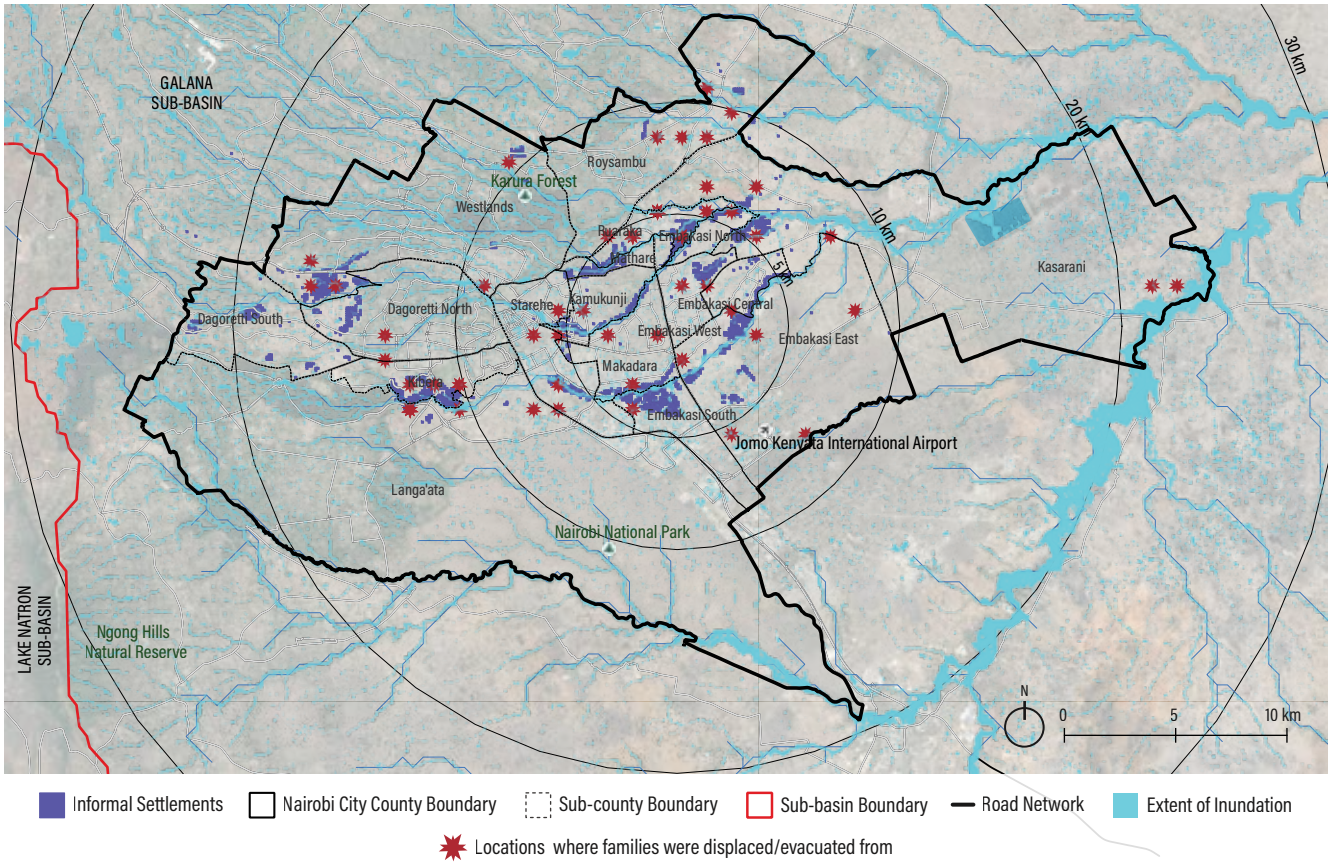
Heavy rains and flooding exacerbate these deficiencies, resulting in the collapse of sanitation infrastructure, which is linked to poor public health outcomes as dilapidated sewers and flooded pit latrines contaminate water sources used for domestic activities. This contamination significantly increases the risk of disease outbreaks (Gichana 2024). Additionally, floodwaters carry sewer seepage and leachate into groundwater and secondary water sources, further compromising access to clean drinking water. Nearly half of Nairobi's population faced damaged water supply systems amid these conditions (Kinyanjui 2024). These challenges underscore a critical need to review flood risk and design for the appropriate infrastructure response within this current environment and urban context.

WRI conducted a spatial analysis to gauge flood impacts on critical urban infrastructure focusing on transportation networks, designated flood shelters, and informal settlements (Appendix A). The city's road network experienced significant waterlogging, particularly at intersections where natural drainage pathways met road embankments, which acted as unintended barriers to water flow. The accumulation of debris in culverts further hindered drainage, causing widespread disruption to urban mobility and public transport services.

Designated flood shelters, mainly schools and places of worship that usually serve as community refuges, were also impacted, becoming waterlogged and inaccessible, thereby reducing available emergency shelter capacity. This placed additional strain on operational shelters, complicating responses to the humanitarian crisis.

The spatial analysis reveals that the most severely damaged infrastructure was consistently located in areas where engineered grey drainage systems lacked complementary green buffers that slow and absorb runoff. This pattern, observed across Mathare, Mukuru, and sections of Kamukunji, is consistent with international evidence showing that integrated GGI can reduce peak flood flows by up to 30–40 percent compared with grey-only approaches, while providing cobenefits for urban heat reduction and biodiversity (Habtemariam et al. 2021; Chu et al. 2019).

Figure 8 | **Locations of household displacement and evacuation in Nairobi City following the MAM 2024 floods**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; flood extent obtained from 2D HEC-RAS model; Relocation data obtained from on-ground survey by SDI; Basin polygon and stream network from FAO Basin Data & FAO Stream Network; Presence of water from JRC Global Surface Water; Google Satellite Basemap.

This spatial analysis provided in Appendix A offers insights into the complex interactions between flooding patterns and urban infrastructure, informing future strategies for disaster risk reduction and resilient urban planning.

Road infrastructure and drainage conflicts

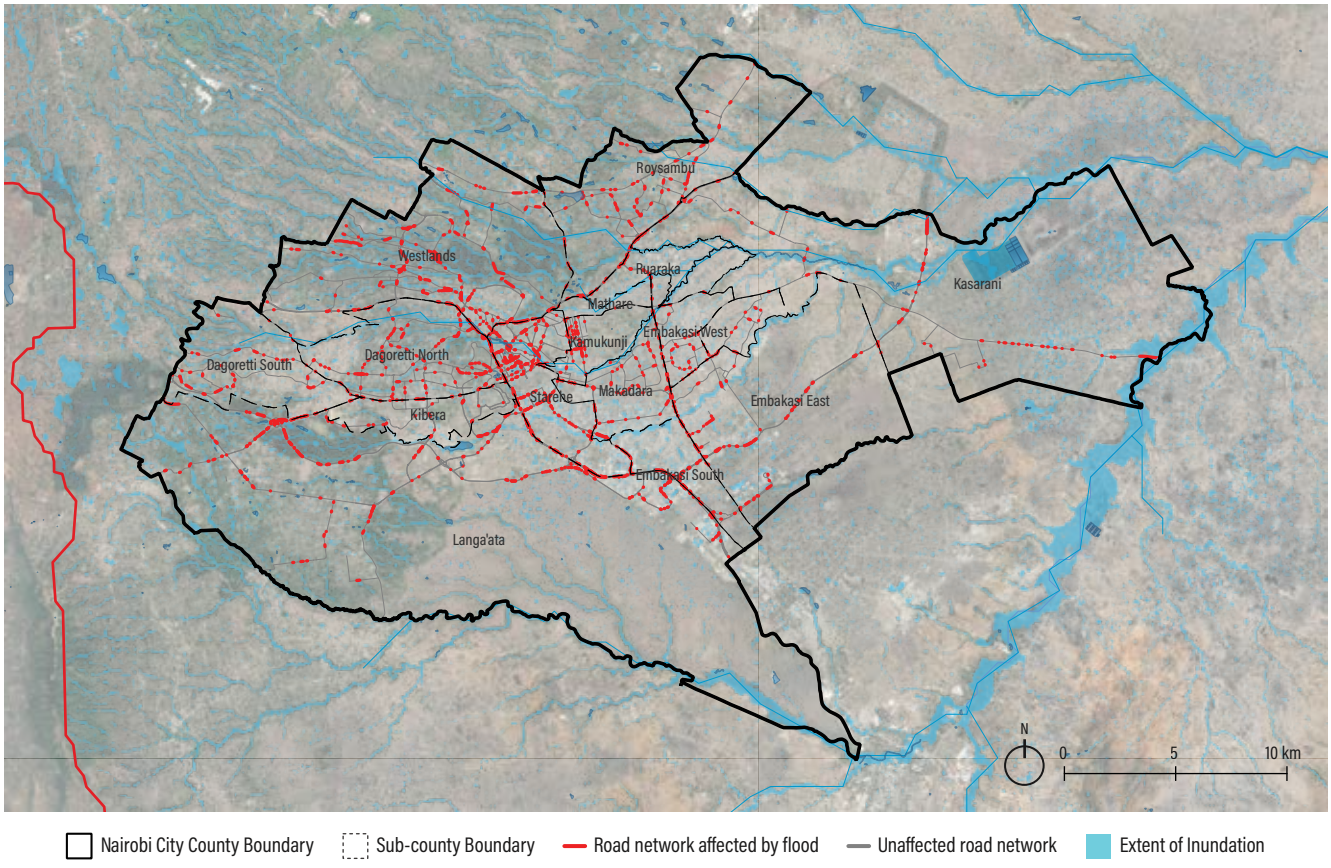
The model developed for this brief (details provided in Appendix A) highlights a clear pattern of waterlogging and surface flooding along major road networks, particularly in the central Kamukunji area. In several instances, roads intersect with natural drainage paths—such as ephemeral streams or perennial watercourses—without sufficient structural provisions like culverts or elevated crossings. This resulted in upstream water pooling and overflow into adjacent residential and commercial zones.

These observations underscore a systemic gap in current infrastructure development. Road projects at both the national and county levels are frequently implemented without sufficient integration of flood management principles or consideration for the health of rivers and sensitive ecological areas. Currently, the implementation of traditional "grey" road infrastructure lacks a comprehensive, overarching drainage and flood design approach. These findings suggest the critical benefits of integrating hydrological data and flood modelling into road infrastructure design to ensure that future projects accommodate the natural movement of stormwater, protect ecological integrity, and reduce downstream impacts. Figure 9 highlights road networks inundated in Nairobi County as a result of the MAM 2024 flooding.

Impact on schools and places of worship

School attendance declined and other social infrastructure was disrupted as families were displaced and multiple facilities repurposed as emergency shelters (Figure 8). Emuhaya Rescue Centre's enrolment dropped from 300 to 169, and Akili Complex's fell from 180 to 160 due to displacement (Elimu Bora Working Group 2024). Schools and places of worship located in areas with limited stormwater management, particularly within informal settlements, were among the most affected (Appendix A). These institutions often serve as key community anchors

Figure 9 | **Road networks inundated by MAM 2024 flooding in Nairobi City County**



Source: County and Sub-county boundaries from Survey of Kenya; flood extent obtained from 2D HEC-RAS model; Road network obtained from OSM; FAO Stream Network; JRC Global Surface Water; Google Satellite Basemap.

and have the potential to act as relief or assembly points during disasters. However, many of these structures were directly affected by floodwaters, underscoring the need to enhance their resilience through better site selection, improved drainage planning, and targeted infrastructure retrofitting.

Public transport disruption and resilience gaps

Flooding also damaged critical public transport infrastructure, including bus stops and high-use corridors, particularly in Kamukunji and parts of Dagoretti North. These areas were highly exposed to flooding, which disrupted public transport operations during periods of intense rainfall. Commuters were stranded across different parts of the city, particularly during peak travel hours in the early mornings and late evenings, as flooding rendered roads and bridges impassable and worsened already severe traffic congestion. Public transport plays a vital role in supporting mobility during and after disasters, particularly for vulnerable populations. Ensuring these nodes are protected from flood risk through improved drainage and flood-proof design could significantly enhance the city's emergency response capacity.

Impact on livelihoods

Over 60 percent of Nairobi's urban population resides in informal settlements, relying heavily on the informal economy for their basic needs (Population Matters 2024). In the aftermath of flooding, residents faced significant livelihood losses due to illness, injury, displacement, and lost work time. Destruction of informal enterprises and residential properties was widespread, with women, who predominantly operate in the informal retail sector, suffering substantial setbacks as their goods were destroyed (Kwao 2024). Vendors in areas like Dandora and Kariobangi reported the complete loss of their stock, leaving them without means to recover their investments (Shamim 2024).

Additionally, urban, peri-urban, and rural food cycles experienced disruptions due to flooding, as farms were ravaged, crops washed away, and livestock drowned in both rural and urban informal settlements (Davies 2024). The city's food supply chain was disrupted because key transport routes were submerged, resulting in food shortages and price increases for staple foods, further straining food vendors, many of whom are women who provide meals to construction and day labourers through roadside kiosks. These vendors play a critical role in both nutrition and livelihood within informal settlements.

During visits to flood-affected zones, WRI engaged with communities evacuated from areas near the river. Despite the evident danger of flooding (Figure 10) many residents sought to return and resettle close to the riverbanks due to proximity to informal employment. The river riparian hosts a financially vulnerable population unable to pay rent in other sections of the settlement due to higher prices.

Resistance to relocation

On the one hand, Nairobi's informal settlements, concentrated in low lying floodplains and riparian corridors, are inherently vulnerable to flooding. This geographic reality suggests that one solution should be to help residents move elsewhere. However, the research highlighted the underlying challenges that make this difficult. Conflicts surfaced between local authorities and residents, as authorities warned of the high risks associated with flood-prone zones. Residents resisted relocation because they relied on income from informal jobs and daily wages concentrated nearby. Proximity to work is essential for their survival. While flooding is a large-scale risk, with broad implications on citywide disaster management policy and action, its impacts on informal settlement dwellers are immediate. Relocation to safer but distant areas disrupts access to jobs and social networks, and limited, costly public transport makes daily survival even more difficult.

Relocation entails a comprehensive socioeconomic transition as well as a physical move. New sites must guarantee not only safety from flooding, but also access to livelihoods, affordable transport, and essential services such as schools, healthcare, and markets. Poorly planned urban relocation can deepen poverty, further fragment social net-

Figure 10 | **Flood mark in a house in Mukuru kwa Reuben which is located in a floodplain**

Source: WRI authors.

works, and exacerbate vulnerabilities, particularly among women, children, and persons with disabilities.

This situation underscores the importance of acknowledging the socioeconomic realities influencing people's choices. Failure to address these livelihood dependencies means that even relocation plans designed with safety in mind are unlikely to be effective. A more integrated approach is critical, emphasising access to affordable transport, livelihood opportunities near resettlement areas, and clear communication about long-term risks. Aligning safety objectives with everyday needs is essential for ensuring that relocation is both sustainable and humane.

Social and behavioural impacts

The compounding effects on life, livelihoods, and infrastructure had significant social and behavioural consequences for a population already facing hardship. The loss of family members, property, and livelihoods, alongside exposure to violence, led to severe psychological distress, particularly among women and children (Kwao 2024). While rescue sites and displacement camps were established for refuge, they became hotspots for violence, particularly affecting women and children (Kenya Red Cross 2024). The protective barriers for minors were often breached as many families were compelled to evacuate to temporary shelters with limited access to food and sanitation. As children were separated from their families during these evacuations, their vulnerability to trafficking and exploitation grew (Kwao 2024).

These challenges placed considerable pressure on community cohesion, leading to documented instances of psychological impacts in community dialogues, alongside moments of solidarity amid shared struggles. However, communities were not just victims, but active agents in post-disaster response and recovery. Community-based organisations (CBOs) were vital in facilitating grassroots disaster response (Davies 2024) and supporting recovery efforts.

Environmental and ecosystem impacts

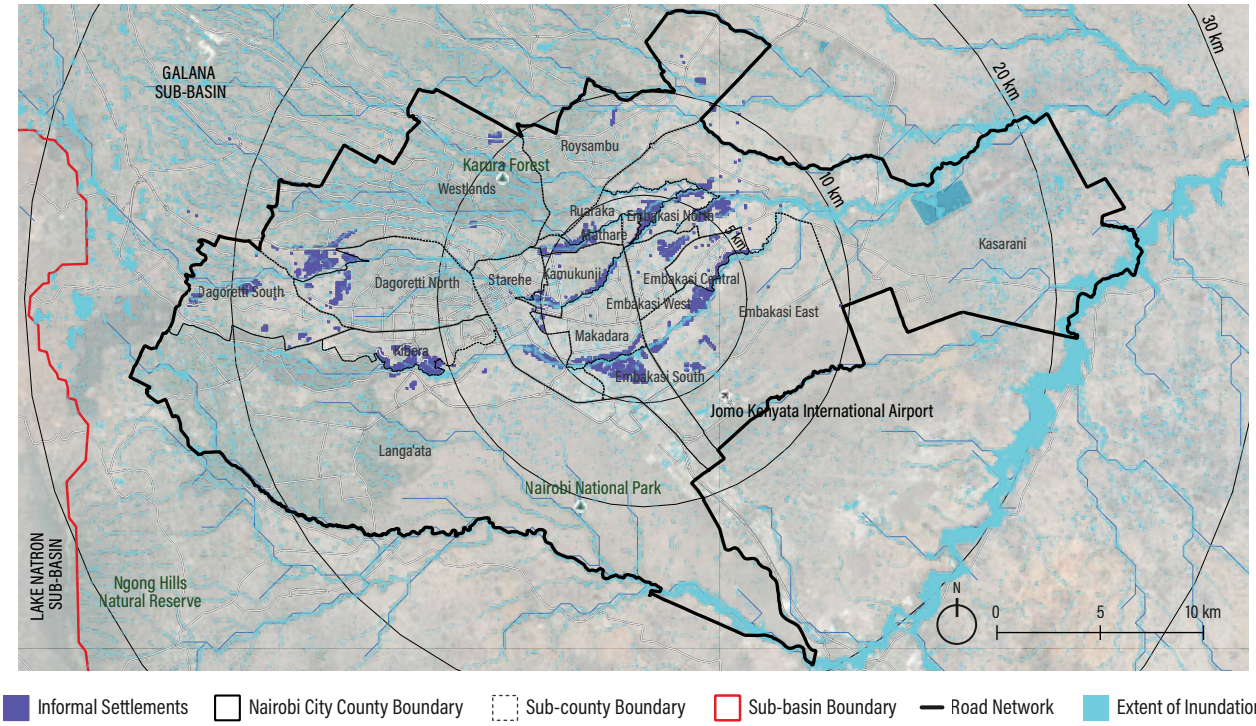
The MAM 2024 floods exposed and deepened a set of pre-existing ecological harms that the built environment has been inflicting on Nairobi's river systems for decades. Understanding these impacts requires distinguishing between two related but distinct processes: the acute environmental damage caused directly by the flood event itself, and the chronic ecosystem degradation which intensified the floods and was in turn further exacerbated by them. The flood model developed for this study (Appendix A) demonstrates that wetlands, which under healthy conditions function as natural sponges of stormwater flow, were rapidly overwhelmed during the April–May 2024 events. Wetlands moderate peak flows by storing runoff and slowly releasing it over time; they also support groundwater recharge, water purification, and soil moisture regulation (Ferreira et al. 2023). When Nairobi's remaining wetlands, albeit degraded, were inundated faster than their capacity to absorb and retain water, these functions ceased, converting areas that should have buffered surrounding communities from flooding into additional channels of inundation. The flood model's spatial outputs (Figure 11) show maximum flood extents on April 29, 2024, confirming that areas with the worst flooding were concentrated precisely in city floodplains where natural buffers including wetland vegetation, riparian corridors, and permeable green spaces have been lost to urban development (WRI 2024).

The floods caused significant riverbank erosion along the Nairobi, Mathare, and Ngong rivers, with high-velocity surface runoff breaking through weakened man-made stormwater channels and exposing bare soil along riverbanks. Where concrete drainage channels and culverts intersected with natural watercourses without adequate hydraulic structures, a pattern identified in WRI's spatial analysis of road infrastructure, upstream pooling caused channel walls to fail, depositing large quantities of sediment and debris into the rivers (WRI 2024). Riparian vegetation that would have stabilised riverbanks and slowed runoff had been largely cleared in preceding years due to the expansion of informal settlements and weak enforcement of land-use regulations. The East African Flood Model framework demonstrates that converting vegetated catchments to built surfaces can increase peak flood magnitude by as much as 20-fold, with consequences including dams breaching, road culverts washing away, and rivers actively scouring their own banks through larger, more erosive flows (Avery 2024). These dynamics were directly observable during the 2024 event.

Building density data indicate that the high concentration of hard surfaces in informal settlements and industrial zones limits rainwater infiltration into the soil (Figure 12). This matters beyond flooding, as reduced infiltration occurs when built surfaces block natural pathways for water to seep into the ground. This directly hinders groundwater recharge which depends on the slow percolation of rainwater through permeable soil to replenish the aquifers that support streamflow and dry-season water supply (Avery 2024).

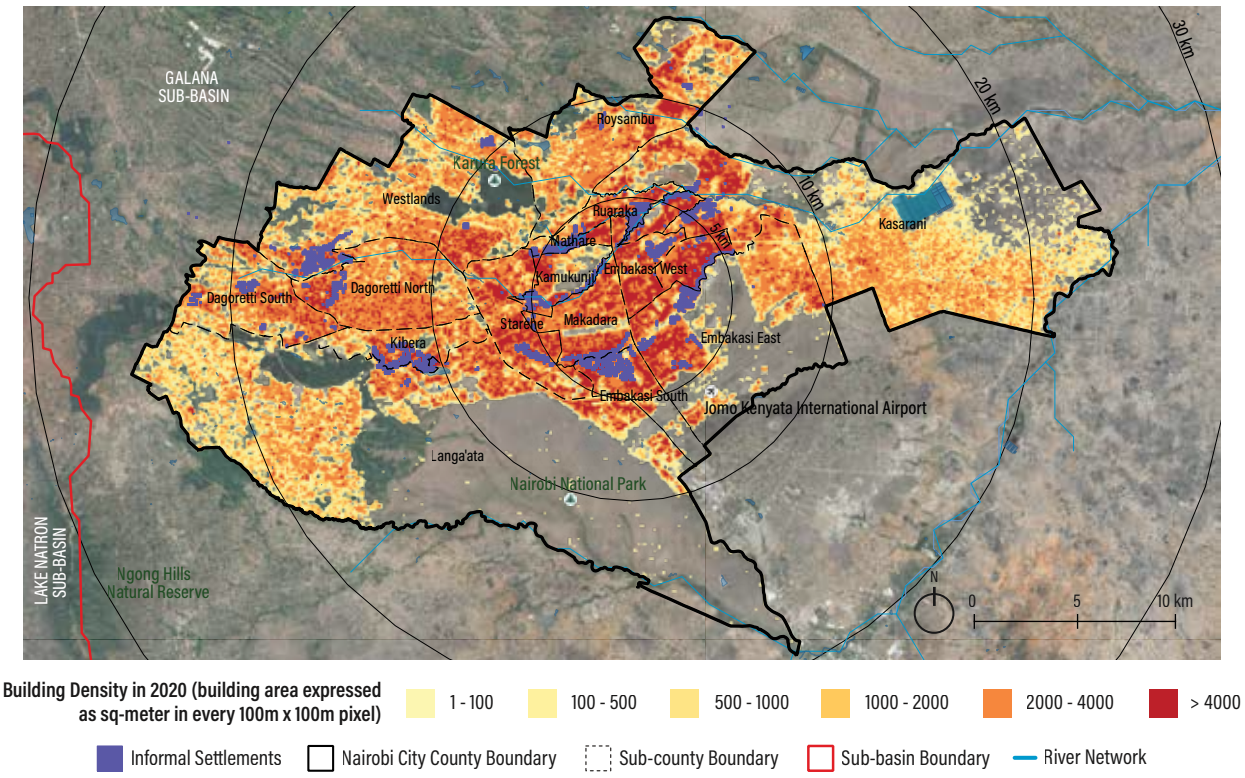
Taken together, these impacts reflect a single underlying dynamic: decades of unmanaged urban development have systematically dismantled the ecological systems that protect Nairobi from the consequences of its own rainfall. The 2024 floods did not cause this dismantling;

Figure 11 | **Nairobi City modelled flood extent for the MAM 2024 torrential rainfall**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; flood extent obtained from 2D HEC-RAS model; Basin polygon and stream network from FAO Basin Data & FAO Stream Network; Presence of water from JRC Global Surface Water; Google Satellite Basemap.

Figure 12 | **Building density in Nairobi City County (2020)**



Source: WRI, County and Sub-county boundaries from Survey of Kenya; GHSL Building Surface; FAO Basin Data; FAO Stream Network; JRC Global Surface Water; Google Satellite Basemap.

they revealed its extent and cost. The government's post-flood response—deploying workers to remove waste from riverbanks, rehabilitate degraded banks, and plant trees along waterways under the Nairobi Rivers Regeneration Programme through NRC—confirms that ecosystem restoration is a necessary part of the recovery effort (Mutura 2025; NRC n.d.). However, as the WRI (2024) analysis and the Nairobi NbS strategic framework highlight, carefully planned ecosystem restoration must be strategically targeted to areas where interventions can most effectively reduce future risk and implemented with meaningful community participation to achieve lasting, large-scale impact.

Gender equity and social inclusion considerations

The 2024 flooding events exposed deep socioeconomic inequalities, disproportionately affecting vulnerable groups such as women, persons with disabilities, and children. Gendered impacts were particularly stark, as structural, cultural, and social inequalities compounded already precarious conditions. Women in informal settlements, especially traders and food vendors, suffered heavy losses from the destruction of goods and market infrastructure. These burdens were further intensified by caregiving responsibilities for children and family health, hindering their economic recovery (Kwao 2024).

Kenya's Constitution (2010) and the National DRM Act (2023) legally require that disaster response be non-discriminatory and protect the rights of vulnerable persons. Evidence from this study reveals that failure to apply these standards, specifically the exclusion of women and persons with disabilities from relief distribution and the absence of GESI-compliant shelters, resulted in measurable welfare deficits for these groups (FELTP 2024; UNICEF 2022). Additionally, recovery efforts did not adequately address the challenges faced by persons with disabilities; they encountered barriers in evacuation and accessing aid due to lack of disability-friendly emergency shelters (Kenya Red Cross 2024).

These challenges highlight the urgent need for planning reforms to rezone and sustainably relocate riverine communities, while ensuring gender- and inclusion-sensitive disaster response and climate-adaptive policies. They also point to the importance of integrating community-based early warning systems (EWS) to capture local perspectives, particularly those of vulnerable groups, and underscore the need for GESI-responsive GGI and community-driven NbS.

Strategies for long-term flood resilience in Nairobi's informal settlements

Community engagement in decision-making to enhance socioeconomic welfare

The findings of this brief make clear that top-down responses to flooding have repeatedly failed Nairobi's most vulnerable residents. During the MAM 2024 crisis, CBOs were the first responders on the ground, collecting household-level damage data and facilitating evacuations faster than formal systems could operate, yet their knowledge and networks were not formally integrated into county or national response structures (WRI 2024). As documented in the Governance section of this brief, sidelining community input caused authorities to miss critical localised knowledge about water flow patterns and safe zones, while response duplication between CSOs and county agencies wasted resources. Building community participation into decision-making is therefore not a procedural preference; it is a practical necessity for effective flood management.

To embed community participation in decision-making, establishing ward- or settlement-level DRR committees is crucial, as recognised in the County Climate Finance Acts. These committees are also key to enabling access to climate finance through programmes such as Financing Locally-Led Climate Action (FLLoCA). Linked to the National Disaster Risk Management Authority under the National Disaster Risk Management Act, 2023, they would provide a formal mechanism for integrating local perspectives into climate resilience planning and emergency response (Republic of Kenya 2023).

Institutionalising these platforms will facilitate coordination with both county and national actors on risk mapping, resource mobilisation, and emergency support. Communities should be equipped with the training and tools needed to design and implement community-based disaster management, including the operation of EWS, risk mapping, and emergency coordination. Both formal and informal community groups should be recognised as implementation partners by county governments and CSOs.

Livelihood programming must be integrated into resettlement planning from the outset, not treated as a separate track. The findings of this brief documented a direct conflict between safety and survival: residents evacuated from flood-prone riparian zones consistently sought to return because proximity to informal employment made relocation economically impossible. A resettlement plan

that does not guarantee access to livelihoods, affordable transport, and essential services will not succeed, and may reproduce the cycle of displacement. Livelihood resilience can be supported through livelihood diversification, promotion of flood-resistant crops and water-efficient urban farming, as well as strengthened public-private partnerships that provide informal workers with micro-credit access for small-scale business start-ups, flexible savings programmes, and emergency cash relief to cushion communities from the economic stress of flood disasters.

Implementation of advanced EWS

This research found that fragmented and delayed community-level flood information directly contributed to mortality during the MAM 2024 crisis, and again in March 2026 when 37 people lost their lives. In both events, the absence of community accessible and timely early warnings meant residents in informal settlements had insufficient time to evacuate. Establishing effective EWS is therefore among the highest-priority recommendations of this brief. Advanced EWS should leverage real-time hydrometeorological data from KMD and predictive analytics to deliver accurate heavy rainfall forecasts. To ensure effectiveness and equity, these systems must be co-designed with local communities, prioritising accessibility and trust. The findings from this brief confirm that community members possess localised knowledge about drainage paths, flood behaviour, and vulnerable households that official systems often lack. Therefore, co-designed EWS can formalise and scale this knowledge.

Policy frameworks should leverage community accessible resources such as mobile phones to disseminate low-cost, decentralised alert mechanisms such as short message service (SMS) notifications, broadcast through community radio, and introduce user-friendly mobile apps for reporting hazards. Given the findings of this brief that persons with disabilities, the elderly, and women in shelters were disproportionately cut off from relief and information during the 2024 floods, last-mile delivery is important: national and county disaster risk management policies should formalise the roles of community health promoters and trained volunteers as first responders, with the legal authority and training to deliver door-to-door alerts to these groups.

Participatory geographic information systems (GIS) mapping, which integrates community knowledge of historical water paths and vulnerable locations into digital systems accessible to ward-level planners, should be embedded in this framework, providing a tool that simultaneously strengthens EWS accuracy and documents localised risk data for ongoing planning. Visual aids like colour-coded flags, flood markers, clear evacuation routes, and designated disaster response facilities and locations should be integrated into urban planning for all riparian areas, with their locations and maintenance funded through NCCG budgets.

Flood-resilient land use planning and NbS

Flood-resilient land use planning must address the three structural drivers identified in this brief as key factors amplifying flood impacts: inadequate drainage, unregulated development on riverbanks, and the expansion of informal settlements into designated floodplains. These are not independent problems; they are connected expressions of the same governance failure documented throughout this brief; failure to enforce laws and plans that already exist.

The most urgent land-use intervention is Systematic Resettlement Action Planning for informal settlements in the highest-risk zones. As this brief documents, the government's 2024 enforcement of the 30-m riparian setback displaced over 40,000 residents without providing safe, affordable housing alternatives, destroyed community-managed water and sanitation assets, and left cleared riparian land largely unplanned, creating the conditions for immediate re-encroachment. A structured Resettlement Action Plan is therefore not a rights-based preference but a practical prerequisite for any durable flood risk reduction: without it, clearance interventions will continue to cycle through displacement and re-encroachment without reducing flood exposure. The resettlement plan must guarantee fair compensation, adequate and accessible housing with proximity to existing livelihoods, and community co-design throughout the process.

Vacated riparian areas must be immediately re-planned as green buffers through strict zoning, preventing further development along the flood-prone banks of the Nairobi, Mathare, and Ngong rivers. Beyond the 30-m riparian setback defined by government, compact, mixed-use developments with integrated permeable surfaces should replace mono-use concrete developments wherever possible, enhancing water infiltration. The spatial analysis conducted for this brief provides actionable insights for infrastructure prioritisation within zones likely to encounter low to moderate flooding beyond the 30-m riparian setback within the informal settlements: schools, places of worship, and healthcare facilities exposed to flooding should be prioritised for foundation elevation, improved local drainage, and where necessary, relocation to sites outside the flood zones to serve as rescue centres during flooding and provide services to residents during other seasons. Roads that cross natural drainage paths should be

upgraded with appropriate culverts and hydraulic structures designed to accommodate a 1-in-50-year rainfall event, in line with the evidence from this brief on the frequency of extreme events.

Citywide adoption and scaling of green-grey infrastructure

The environmental impacts documented in this brief—including degraded wetlands, riverbank erosion, and reduced groundwater recharge—confirm that Nairobi cannot effectively manage flood risk through grey engineering alone. Systematic loss of the natural buffers that once moderated the city's hydrology means that engineered drainage channels are now expected to carry loads they were never designed for. GGI, combining NbS with conventional engineering, is the approach with the strongest evidence base for addressing this gap cost-effectively.

NbS, including constructed wetlands, riparian buffer zones, urban forests, bioswales, and permeable pavements should be incorporated into all river engineering proposals. These are not supplementary landscaping features: a meta-analysis of green infrastructure studies found they can reduce stormwater peak flows by 30–94 percent. Evidence from the NbS initiative's Nairobi pilot sites, including Mukuru kwa Reuben, similarly documented reduced localised flooding, improved stormwater management, and fewer school disruptions during periods of heavy rainfall following implementation (African Cities Database 2026). Restoring polluted riparian landscapes and protecting green corridors improves water retention and reduces the toxic pollution load flushed into rivers from industries and solid waste during flood events, directly addressing the water quality degradation documented in this brief.

At the same time, Nairobi must upgrade its aging grey infrastructure, which was designed in the 1970s for a fraction of the current urban footprint. Existing networks are inadequate, particularly in rapidly growing informal settlements located in low-lying flood zones, where stormwater and sewerage systems are often damaged or non-existent. Strategic enhancements should include levees, detention reservoirs, stormwater tunnels, and mechanical pump stations in high-risk areas to manage acute flooding events (Habtemariam et al. 2021). Wherever grey upgrades are planned, their design should integrate green elements such as constructed wetlands alongside concrete channels, permeable paving along drainage corridors, and vegetated retention areas at road–watercourse intersections. Co-designing these hybrid systems with local communities is essential for both project integrity and long-term maintenance (Collins et al. 2025).

City authorities must embed GGI into all planning and budget frameworks. For instance, county spatial plans, capital expenditure budgets, and environmental and social impact assessment requirements should all include explicit GGI provisions. Donors and development finance institutions should support Nairobi in building a pipeline of bankable GGI projects, prioritising the most marginalised communities. All investments must be accompanied by a robust monitoring, evaluation, and adaptation system to track flood outcomes and adjust approaches as the city's climate risk evolves (Chu et al. 2019; Habtemariam et al. 2021).

Box 2 presents case studies of successful GGI projects implemented at different scales. These could serve as lessons to address Nairobi's flood risk.

Coordinated policies and governance for disaster risk reduction

Effective flood risk management is hindered by weak coordination across national and county governments, as well as non-state actors, compounded by limited capacity at the county level. National bodies such as the NSCDR and the Office of Special Programmes operate with minimal integration into county structures, undermining local implementation despite the National Adaptation Plan (NAP) prioritising flood control. To address this, legal and institutional reforms should establish a clear, statutory coordination framework that delineates and enforces the roles of the NCCG, NDOC, NEMA, WRA, NRC, KURA, and the National Construction Authority (NCA) in flood risk management, with a single lead agency accountable for integrated flood risk outcomes. The NSCDR's mandate should be strengthened, and inter-agency protocols operationalised to support joint planning, not only during disaster events but also in advance of them. A Nairobi-specific DRR strategy should be developed and directly integrated into the County Integrated Development Plan (CIDP) and annual county budgets. This is the only mechanism that would guarantee statutory funding and sustained implementation.

To protect natural buffers, enforcement of existing land-use regulations must be strengthened; however, enforcement alone is insufficient. The evidence from this brief shows that enforcement without coordinated follow-through creates its own harms. For example, riparian clearance that is not accompanied by resettlement planning, replanting, and community management simply transfers vulnerability rather than reducing it. A structured land reclamation programme for floodplains and flood-prone areas with dedicated funding, a community-led digital monitoring system, and a transparent accountability mechanism tracking which cleared land is being

Box 2 | Case studies of successful NbS and GGI projects

Case study 1: Beira, Mozambique

Beira, a coastal city in Mozambique, faces severe climate-related risks as demonstrated by the devastating impacts of Cyclone Idai in 2019. To combat flooding in low-income communities, the city employs a mix of green-grey solutions backed by the World Bank's Cities and Climate Change Project. This includes upgrading drainage systems and restoring the Chiveve River, previously affected by pollution, mangrove loss, and flooding. Community initiatives began with mangrove restoration and river clean-ups, followed by widening the tidal basin and building a controllable tidal outlet. A 17-hectare (ha) multi-functional urban park was also created, projected to protect 50,000 people from flooding and improve waste management, while upgraded drainage systems will safeguard an additional 234,000 residents, all living within the neighbouring informal settlements (World Bank 2022).

Case study 2: SUNCASA initiative in Dire Dawa, Kigali, and Johannesburg

The Scaling Urban Nature-Based Solutions for Climate Adaptation in Sub-Saharan Africa (SUNCASA) initiative exemplifies inclusive, community-led climate adaptation using NbS. Working in Dire Dawa, Kigali, and Johannesburg, the project engages local communities—including women and vulnerable groups—in co-designing and implementing solutions like riverbank rehabilitation, tree planting, and watershed restoration to reduce urban flooding and climate risks. In Dire Dawa, SUNCASA focuses on restoring the Dechatu River catchment; in Kigali, it rehabilitates six micro-catchments of the Nyabarongo River; and in Johannesburg, it works on the Jukskei River catchment. These interventions are expected to directly benefit approximately 2.2 million people living in high-flood-risk areas, and an additional 7 million urban residents through increased resilience to water stress, heat, landslides, and soil erosion. Beyond environmental benefits, SUNCASA promotes social equity and biodiversity, empowering communities—especially women—to actively participate in climate action and decision-making (WRI n.d.).

Case study 3: uMngeni River catchment restoration, Durban, South Africa

In the early 2010s, Durban launched a multi-stakeholder initiative to protect the uMngeni River catchment through ecological infrastructure, enhancing water supply and disaster risk reduction. This resulted in the Durban Metropolitan Open Space System, a 94,000-ha nature reserve that supports biodiversity and vital ecosystem services. Collaboration with residents from flood-prone informal settlements was key, leading to ecosystem-based adaptation strategies that improved community water security. A vital lesson learned was the importance of fostering relationships among local residents, researchers, and government officials (Habtemariam et al. 2021).

actively restored versus left vacant, is essential to ensure that enforcement delivers ecological benefits rather than displacement. Unless these critical natural drainage systems are reclaimed and restored, all other flood mitigation interventions will likely fail. Future zoning bylaws and building codes must be updated to explicitly incorporate flood risk, addressing the pattern of unregulated construction along watercourses, including riparian areas, as documented throughout this brief.

Innovative financing mechanisms for long-term resilience

Approximately 80 percent of Kenya's DRR-related spending has historically gone to emergency response rather than proactive risk reduction, and less than 2 percent of climate finance globally flows to NbS (Food and Land Use Coalition 2022; UN Office for Disaster Risk Reduction (UNDRR) 2018). Reversing this balance requires both unlocking new finance and redirecting existing allocations. To enhance long-term flood resilience in Nairobi's informal settlements, financial strategies must prioritise increased investment in locally-led NbS (e.g., restoring wetlands and riparian buffers), community-driven drainage infrastructure, and affordable flood-resilient housing. Crucially, these interventions should leverage specific local assets to generate economic value; for instance, Dandora Falls holds significant potential as a tourism site and a source of small-scale hydropower (Figure 13). It could energise riverine activities while generating revenue streams to support riverine resilience goals. However, to realise these opportunities, it is vital to capture and activate financing pathways that are not yet fully operationalised, as current gaps limit the ability to mobilise necessary funding. Strategies must explicitly link resilience actions to specific financing instruments and clearly outline the steps required to access these funds.

Figure 13 | **Dandora Falls and surrounding Dandora settlement**

Source: WRI (2025).

Blended finance mechanisms, combining public funds, donor grants, and private capital can de-risk investments and support scalable interventions. The FLLoCA programme is Kenya's most significant existing vehicle for this purpose. As of 2024, this flagship initiative had disbursed KSh 12.68 billion to 45 counties and 1418 wards, supporting over 1178 active projects including flood preparedness, land rehabilitation, and EWS (World Bank 2024). It is financed through $150 million in International Development Assistance (IDA) credit, co-financing from Germany's KfW, and bilateral support from Denmark, the Netherlands, and Sweden (World Bank 2024). FLLoCA's architecture, performance-based grants tied to measurable county-level outcomes, aligned with the CIDP, and requiring ward climate change planning committees as a disbursement condition, makes it a great example for scaling the flood resilience investments recommended in this brief. Nairobi County should prioritise meeting and maintaining FLLoCA eligibility conditions to unlock these resources.

Beyond FLLoCA, the National Treasury should establish a dedicated Urban Resilience Fund. This fund, aligned with the Sendai Framework monitoring indicators and supported by multi-lateral development finance, could provide sustained multi-year financing for large-scale GGI upgrades that exceed individual ward-level financing capacity. Micro-insurance schemes and community savings groups can offer financial buffers to vulnerable households, incentivizing local participation in maintenance and EWS. To operationalise these mechanisms, strategies must explicitly map resilience actions to specific financing instruments and clearly outline the practical steps required to access them. This would help address bureaucratic delays in fund disbursement and limited grassroots capacity to design catalytic NbS proposals, both of which currently hinder the flow of available finance to communities.

Prioritised flood risk management actions, timelines, and institutional roles

Table 1 presents a sequence of the implementation of the proposed recommendations, their timelines and institutions responsible for implementation.

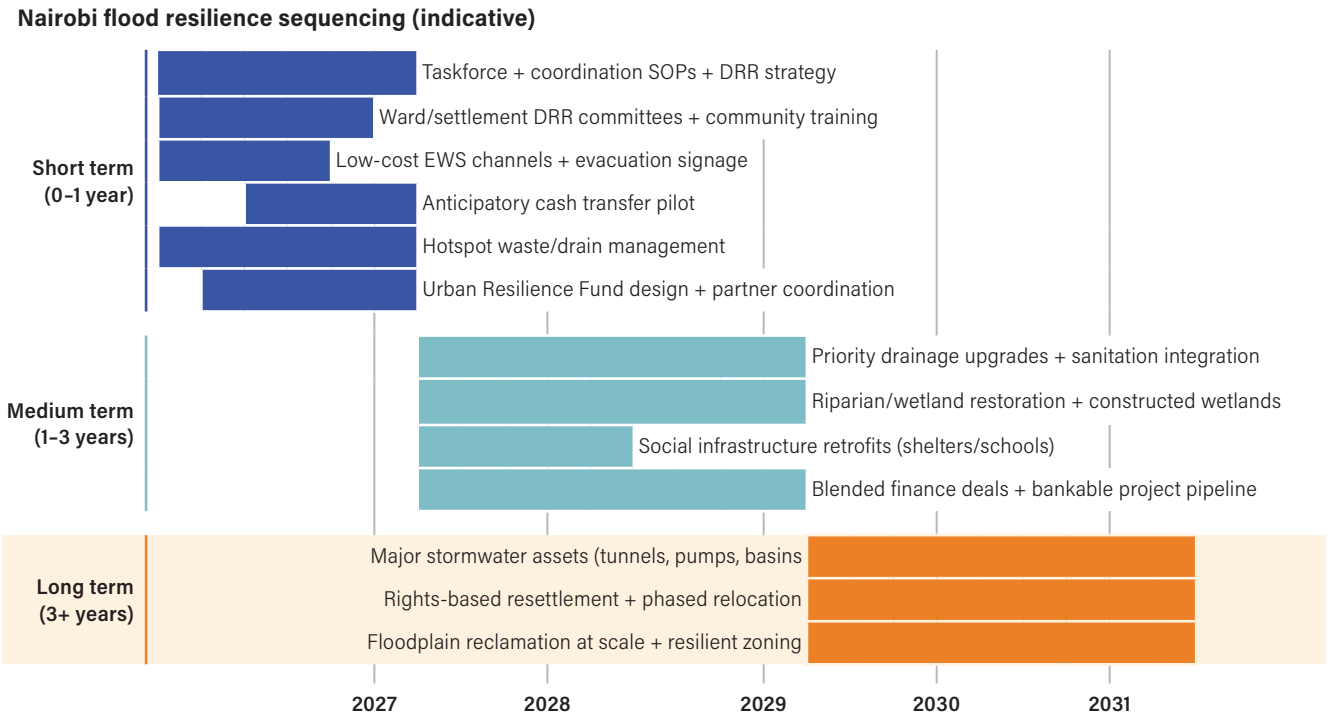
Figure 14 presents a summary of proposed activities and timelines for flood risk management.

Table 1 | **Proposed action areas, timelines and implementing institutions**

TIMEFRAME	ACTION AREA	KEY ACTIONS	LEAD INSTITUTION(S)	SUPPORTING ACTORS
Short-term (0–1 year)	**Disaster preparedness and early warning**	Strengthen multi-hazard EWS, anticipatory action, and community-based alert mechanisms	NDOC, NCCG Disaster Unit	Kenya Red Cross, CBOs, local administration
	Community engagement and resilience	Establish community DRR committees, strengthen first response capacity, and improve access to safe shelters	NCCG	CBOs, nongovernmental organisations (NGOs), Kenya Red Cross
	Policy enforcement (risk reduction)	Enforce riparian regulations, prevent encroachment, and strengthen compliance in high-risk flood zones	NCCG, NRC	NEMA, WRA, local administration
Medium-term (1–3 years)	**Flood-resilient planning and NbS**	Integrate flood risk into land-use planning; restore riparian buffers, wetlands, and floodplains using NbS	NCCG (Planning, Environment)	NRC, Ministry of Lands, *Kenya Forestry Research Institute (KEFRI)*
	GGI	Upgrade drainage systems and deploy integrated GGI: Sustainable Urban Drainage Systems (SUDS), retention systems, green spaces	NCCG (Public Works, Environment, Planning)	Development partners, private sector
	Financing mechanisms	Establish blended finance models, resilience funds, and budget reallocations toward risk reduction investments	NCCG, National Treasury	Development partners, private sector
Long-term (3+ years)	**Institutional coordination and governance**	Strengthen multi-sectoral coordination frameworks, clarify mandates, and institutionalise DRR in planning systems	NCCG, National Government	NDOC, NRC, development partners
	Ecosystem restoration at scale	Restore upstream catchments and river systems to enhance flood regulation and ecosystem services	NRC, NCCG	KEFRI, communities, civil society
	Sustainable financing systems	Operationalise long-term climate finance pipelines, including private sector investment and insurance mechanisms	NCCG, National Treasury	Development partners, financial institutions

Source: WRI authors.

Figure 14 | **Nairobi flood risk management proposed timelines**



Source: WRI Authors 2026.

Conclusion and call to action

Nairobi's MAM 2024 floods revealed how a meteorological event becomes a humanitarian and infrastructural crisis when systemic weaknesses and governance gaps remain unaddressed. The findings highlight that it was not the climate hazard alone that determined outcomes. Rather, increased exposure through the rapid growth of informal settlements in floodplains, degraded natural buffers, encroachment in riparian zones, and underinvestment in resilient drainage and social protections amplified the event's impacts. Evidence from 2026 confirms that the trajectory is worsening.

Effective resilience requires coordinated, equity-centred interventions that address both physical systems and social vulnerability. These must be enabled by political will, multi-stakeholder coordination, and sustained financing that centres the voices and needs of informal settlement residents. To achieve long-term resilience, we recommend the following:

- Strengthened enforcement of flood-resilient land use plans and structured reclamation of riparian land.
- Scaling integrated GGI with upgraded drainage and NbS.
- Implementing advanced EWS.
- Engaging communities in co-creating interventions to maximize socioeconomic benefits.
- Coordinating policies and governance for disaster risk reduction with linkages between communities and city ward committees.
- Creating transparent blended finance mechanisms such as an Urban Resilience Fund to sustain investments and track progress.

These measures must be implemented in tandem; engineering upgrades without social protections, or enforcement without safe relocation options will reproduce harm rather than reduce it.

Building Nairobi's long-term resilience to future flooding events requires a whole-of-society approach, with a focus on the city's informal settlements. We propose a four-point Call to Action that places vulnerable communities at the centre of planning, financing, and implementation efforts, advancing integrated solutions that reduce flood risk and support a just, resilient recovery.

CALL TO ACTION: ADVANCING RESILIENT SOLUTIONS IN NAIROBI'S INFORMAL SETTLEMENTS

1. **Prioritise the most vulnerable in the design and implementation of all flood resilience strategies** by creating an enabling environment for communities to meaningfully participate at all stages. To support this, the city should establish a **formal coordination mechanism targeting the urban vulnerable communities** through established commissions and agencies such as NRC, or create a dedicated flood resilience taskforce to ensure inclusive, sustainable representation in decision-making, planning, and oversight of climate resilience actions.
2. **Advocate for the integration of GGI considerations into all city-wide plans, *strategies, and policies*** for Nairobi, including NbS. These integrated systems, which combine ecological and engineered infrastructure (e.g., wetlands, bioswales, and stormwater tunnels), are vital to reducing flood vulnerability, protecting human health and livelihoods, and enhancing long-term urban sustainability in the face of increasing climate risk. This integration should be grounded in **proactive, multi-sectoral urban planning frameworks** with strategies to upgrade informal settlements with climate-resilient infrastructure or, where needed, provide guidelines on **relocating households humanely and in phases to safer zones, embedded within city action plans.**
3. **Mobilise increased investment in climate-resilient infrastructure and services** *for* the scaling of financial resources toward inclusive and locally grounded flood resilience efforts. This includes financing for community-led NbS, community-driven drainage and sanitation systems, and the development of affordable, flood-resilient housing. Innovative mechanisms such as public-private partnerships, climate adaptation funds, and micro-financing for informal settlement dwellers should be prioritised to close implementation gaps. To anchor these investments, Nairobi should establish a **dedicated Urban Resilience Fund**, supported by both the county and national governments, and design a **cash transfer programme linked to EWS** to provide timely financial support to vulnerable households, enabling proactive flood preparedness and post-flood recovery.
4. **Champion the adoption of evidence-driven decision-making** using data on climate risks and vulnerability co-created with vulnerable communities and other local stakeholders, and mainstream this in urban spatial planning and decision-making.

Appendices

Appendix A: Two-dimensional hydrodynamic flood simulation model

Geospatial data from open sources analysed by WRI was used to conduct a flood causes and impacts analysis, including through development and analysis of maps such as digital elevation models (DEMs), topography and hydrology, land use and land cover change (derived from ESA WorldCover 10-m resolution), population growth (*Global Human Settlement Layer* (GHSL) Population 2020) and rainfall climatology, among others. The findings from these analyses have informed holistic GESI-responsive recommendations aimed at addressing flooding risks and enhancing the city's resilience.

To accurately recreate the devastating April and May 2024 floods in Nairobi, we developed an unsteady two-dimensional, physically based hydrodynamic model, HEC-RAS. The model uses a 2D form of the Saint-Venant equation, also known as the shallow water equation, that accounts for local and convective acceleration, pressure gradient, bed friction, turbulence, wind stress and Coriolis effects. This model focused on the upper reaches of the Galana basin, the expansive river system that encompasses Nairobi County.

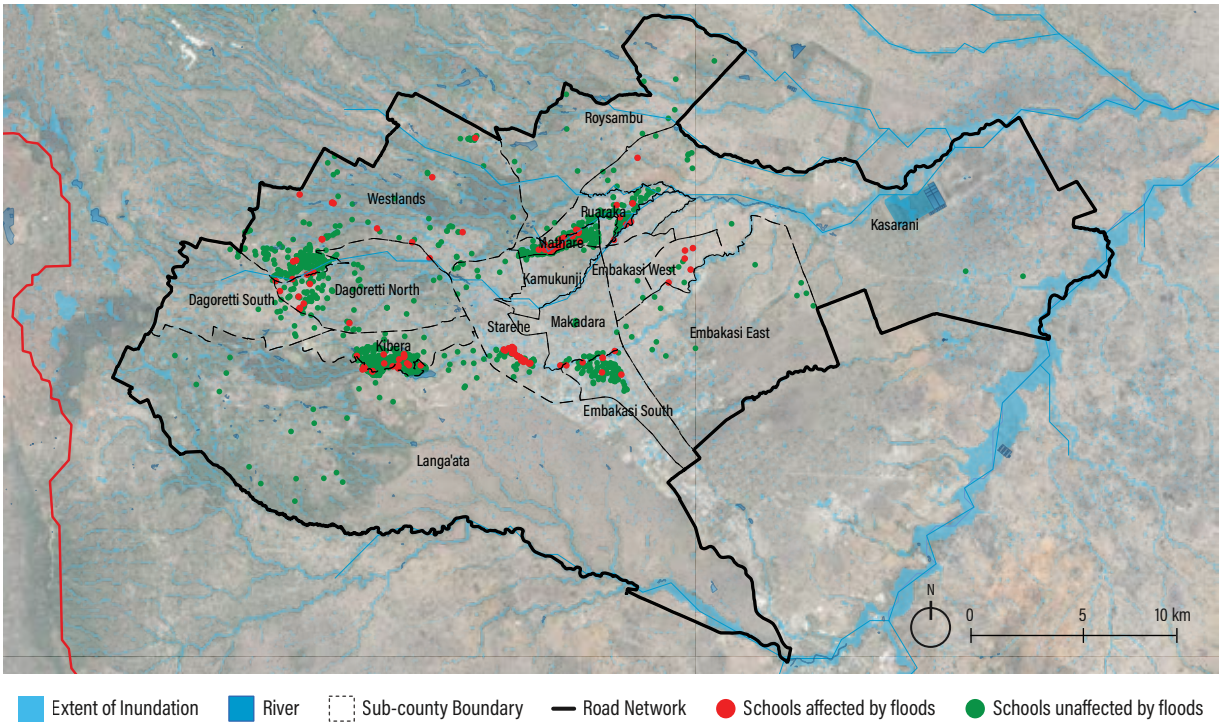
To bring this digital environment to life, we integrated several key pieces of open-source geospatial data. The topography of the area was mapped using DEM derived from FABDEM data, providing detailed elevation information at a 30-m resolution. We also incorporated land-use types from ESA WorldCover 2021 (10-m resolution) to understand how different surfaces like urban areas or vegetation could influence water flow. Finally, the characteristics of the upper soil layer were factored in using FAO Soil data (250-m resolution) which is crucial for understanding how much water the ground can absorb. All these diverse datasets were seamlessly integrated within HEC-RAS to create a realistic simulation of the flood event.

The model was driven by rainfall data spanning a three-month period from March to May 2024. This rainfall information was sourced from JAXA Realtime Rainfall Watch GSMaP, offering a comprehensive view of precipitation at a 0.1-degree spatial resolution (roughly 11.1 km at the equator) and an impressive one-hour temporal resolution. To ensure the accuracy of our rainfall input, we diligently correlated the GSMaP data with ground-based observations from KMD, and found strong agreement between the two datasets.

The simulations ran with a fine five-second time-step throughout the March to May 2024 period. We observed that the maximum modelled flood extent occurred on April 29, 2024. To ensure our model's outputs were as accurate as possible, we calibrated the model by adjusting parameters like Manning's N Roughness (which accounts for friction on the landscape) and the Curve Number (which helps estimate runoff).

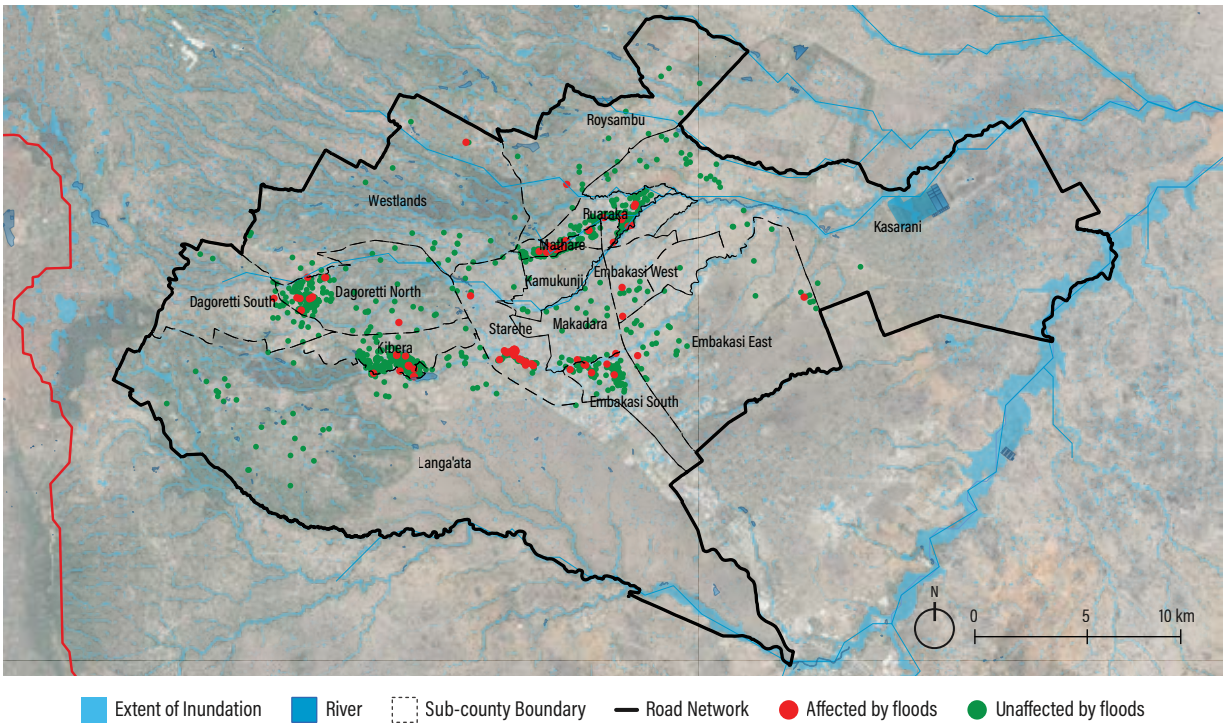
The validity of our model was rigorously checked through a two-pronged validation approach. First, we conducted a crucial door-to-door survey in two informal settlements situated along the Mathare and Ngong rivers. This direct engagement with affected communities provided invaluable qualitative feedback on the flood's impact. Next, we carried out a second round of validation to identify high flood marks left behind on infrastructure after the deluge. These physical traces provided concrete evidence to compare against our simulated flood extents.

Figure A-1 | **Schools affected by flooding in Nairobi**



Source: County and Sub-county boundaries from Survey of Kenya; flood extent obtained from 2D HEC-RAS model; School locations obtained from OSM; FAO Basin Data; FAO Stream Network; JRC Global Surface Water; Google Satellite Basemap.

Figure A-2 | **Places of worship affected by flooding in Nairobi**



Source: County and Sub-county boundaries from Survey of Kenya; flood extent obtained from 2D HEC-RAS model; Locations of places of worship obtained from OSM; FAO Basin Data; FAO Stream Network; JRC Global Surface Water; Google Satellite Basemap.

Appendix B: Nairobi household survey

Section A: Demographics

GPS LOCATION (AUTO-CAPTURE ENABLED)

Where does the respondent live?

1. Mathare Valley Informal Settlement
2. Mukuru Viwandani

How long have you been living in this settlement?

1. Less than a year
2. 1–5 years
3. 6–10 years
4. 11–15 years
5. Over 15 years

Gender of respondent:

1. Male
2. Female
3. Other

What is your household size?

1. 1–3
2. 4–6
3. 7–10
4. Over 10

SECTION B: FLOOD IMPACT ASSESSMENT

Have you experienced flooding in the past? (Yes/No)

If yes, how frequently have you experienced flooding?

1. Once
2. Rarely (1–2 times a year)
3. Occasionally (3–5 times a year)
4. Frequently (more than 5 times a year)

How has flooding impacted your household? (Select all that apply)

1. Damage to property
2. Displacement
3. Health issues
4. Reduced income opportunities
5. Disruption of school attendance
6. Other (Specify)

Occupation (before floods):

1. Full-time employment (formal sector)
2. Full-time employment (informal sector)
3. Part-time/casual wage employment (formal sector)
4. Part-time/casual wage employment (informal sector)
5. Own formal sector business
6. Own informal sector business
7. Unemployed
8. Student
9. Other (Specify)

Occupation (after floods): (Same categories as above)

How many household members earn an income?

1. 1–2
2. 3–4
3. Above 4

Has flooding affected your sources of income? (Yes/No)

If yes, how?

1. Job loss
2. Reduced earnings
3. Loss of business
4. Other (Specify)

Have you experienced property loss due to flooding? (Yes/No)

If yes, state the type of loss:

1. Total house damage
2. Partial house damage
3. Household items washed away
4. Damage to household items
5. Damage to business premises
6. Damage to business stock
7. Other (Specify)

Estimated value of property loss:

1. Less than KSh 5,000
2. KSh 5,001–10,000
3. KSh 10,001–20,000
4. KSh 20,001–30,000
5. KSh 30,001–40,000
6. KSh 40,001–50,000
7. Over KSh 50,000

Health risks experienced during flooding:

1. Waterborne diseases
2. Injuries

3. Mental stress
4. Other (Specify)

Are there health issues directly related to flooding? (Yes/No)

If yes:

1. Diarrhoea
2. Cholera
3. Typhoid
4. Malaria
5. Respiratory complications
6. Skin infections
7. Eye irritations
8. Other (Specify)

SECTION C: SOCIOECONOMIC ADAPTATIONS

What measures have you taken to cope with flooding?

1. Elevated house
2. Drained water from house
3. Sought shelter (school, church, etc.)
4. Relocation
5. Other (Specify)

Have you received support to cope with flooding? (Yes/No)

If yes, state the type of support:

1. Financial support
2. Material support
3. Informational support

Source of support:

1. National Government
2. County Government
3. NGOs
4. FBOs
5. CBOs
6. Family
7. Friends and Neighbours
8. Other (Specify)

How has flooding affected your daily routine?

1. Disruption of work
2. Economic/livelihood disruption
3. Loss of houses
4. Children missing school
5. Difficulty in transportation
6. Other (Specify)

Changes in social interactions after flooding? (Yes/No)

If yes:

1. Increased community support
2. Reduced community support
3. Increased social activities
4. Reduced social activities
5. Other (Specify)

SECTION D: DEMOLITIONS AND RIPARIAN ZONE IMPACT

Are you familiar with the term 'Riparian'? (Yes/No)

Were you affected by recent demolitions after flooding? (Yes/No)

If yes, how?

1. Physical displacement
2. Psychological stress
3. Loss of property
4. Loss of livelihood
5. Loss of learning centre for children
6. Loss of social amenities (toilets, church, halls)
7. Other (Specify)

How safe do you feel post-flooding and demolitions?

1. Very safe
2. Safe
3. Neutral
4. Unsafe
5. Very unsafe

Have you received support after demolition?

1. Financial support
2. Material support
3. Informational support
4. Psychological support

If yes, who provided support?

1. National Government
2. County Government
3. NGOs
4. FBOs
5. CBOs
6. Family
7. Friends and Neighbours
8. Other (Specify)

Do you think flooding affects men and women differently? Please explain.

Main concerns for the future:

1. Future flooding
2. Loss of income
3. Urban heat
4. Health risks
5. Housing security
6. Other (Specify)

How hopeful are you about the future?

1. Very hopeful
2. Hopeful
3. Neutral
4. Pessimistic
5. Very pessimistic

SECTION E: PROPOSALS

What interventions can help mitigate flooding?

1. Improved drainage systems
2. Early warning systems
3. Relocation programmes
4. River cleaning
5. Road improvement
6. Greening of river riparian
7. Community education
8. Other (Specify)

How can government better support residents?

1. Financial aid
2. Infrastructure development
3. Housing provision
4. Provision of open spaces
5. Machinery for river cleaning
6. Information dissemination
7. Health services
8. Other (Specify)

Do you have additional experience related to flooding? (Yes/No)

If yes, please share.

Flood Extent Validation Survey

This questionnaire is designed to collect detailed field-based information on flood extent, depth, and impacts on infrastructure and surrounding communities.

SECTION 1: ENUMERATOR AND LOCATION DETAILS

1. Surveyor Name: _____

2. Name of Settlement/ Neighbourhood_____

3. GPS Location (Auto-capture enabled)

SECTION 2: FLOOD EXTENT VALIDATION

4. Does the flood extent shown on the map match the flood extent observed on the ground?

☐ Yes

☐ No

(Enumerator: Kindly speak with local residents to verify historical and observed flood extent.)

5. What was the average depth of floodwater in this area?

☐ Shallow (0–0.5 metres)

☐ Moderate (0.5–1.5 metres)

☐ Deep (1.5 metres and above)

6. Provide specific flood depth measurements if possible (in metres):

_____

_____

7. Are there observable watermarks or high-water marks indicating the highest flood level? (use an object which can be used as a scale)

☐ Yes

☐ No

If yes, describe the evidence and reference object used for scale:

_____

_____

8. Take a geo-referenced photo of the site and visible flood markers (Ensure an object is included in the frame to serve as a scale reference.)

List of Abbreviations

AAK	Architectural Association of Kenya
ACRC	African Cities Research Consortium
ADOE-CC	Assistant Director of Environment, and Climate Change
AMT	Akiba Mashinani Trust
AQM	Air Quality Monitoring
ARIN	African Research and Impact Network
CADP	County Annual Development Plan
CAHF	Centre for Affordable Housing Finance
CBA	community-based approach
CBD	central business district
CBO	community-based organisation
CIDP	County Integrated Development Plan
CSO	civil society organisation
CSP	County Spatial Plan
DEM	Digital Elevation Model
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DTM	Digital Terrain Model
EMCA	Environmental Management and Coordination Act
ESA	European Space Agency
EWS	early warning system
FABDEM	Forest and Buildings removed Copernicus Digital Elevation Model
FAO	Food and Agriculture Organization of the United Nations
FBO	faith-based organisation
FELTP	Field Epidemiology and Laboratory Training Programme
FGD	focus group discussion
FLLoCA	Financing Locally-Led Climate Action
FY	financial year
GCA	Global Centre on Adaptation
GESI	gender equity and social inclusion
GGI	green–grey infrastructure
GHSL	Global Human Settlement Layer
GIS	geographic information system
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GPS	Global Positioning System
HEC-RAS	Hydrologic Engineering Centre's River Analysis System
IDA	International Development Assistance
ISRIC	International Soil Reference and Information Centre
JAXA	Japan Aerospace Exploration Agency
JICA	Japan International Cooperation Agency
KDI	Kounkuey Design Initiative
KEFRI	Kenya Forestry Research Institute
KeNAWRUA	Kenya National Association of Water Resources Users Associations
KeNHA	Kenya National Highways Authority
KeRRA	Kenya Rural Roads Authority
KfW	Kreditanstalt für Wiederaufbau/German Development Bank
KIP	Kenya Institute of Planners
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KMD	Kenya Meteorological Department
KNBS	Kenya National Bureau of Statistics
KSh	Kenya shilling
KURA	Kenya Urban Roads Authority
MAM	March, April, May
NABREP	Nairobi Rivers Basin Regeneration Programme
NAP	National Adaptation Plan
NbS	nature-based solutions
NCA	National Construction Authority
NCCG	Nairobi City County Government
NCWSC	Nairobi City Water and Sewerage Company
NDOC	National Disaster Operations Centre
NEMA	National Environment Management Authority
NGEC	National Gender and Equality Commission
NGO	nongovernmental organisation
NIUPLAN	Nairobi Integrated Urban Development Master Plan
NRC	Nairobi Rivers Commission
NSCDR	National Steering Committee on Disaster Response

PSN	Public Space Network
RIA	Resilience Initiative Africa
SDG	Sustainable Development Goal
SDI-K	Slum Dwellers International – Kenya
SESDO	Social and Environmental Sustainable Development Organization
SMS	Short Message Service
SOP	standard operating procedure
SUDS	Sustainable Urban Drainage Systems
SUNCASA	Scaling Urban Nature-based Solutions for Climate Adaptation in Sub-Saharan Africa
UDELC	Urban Development, Environment and Land Use Consultants
UHI	urban heat island
UN	United Nations
UN-Habitat	United Nations Human Settlements Programme
UNDP	United Nations Development Programme
UNDRR	UN Office for Disaster Risk Reduction
UNICEF	United Nations Children's Fund
UNU-WIDER	United Nations University World Institute for Development Economics Research
UoN	University of Nairobi
WASH	water, sanitation, and hygiene
WCCPC	Ward Climate Change Planning Committee
WRA	Water Resources Authority
WRI	World Resources Institute
WWF	Worldwide Fund for Nature

Endnotes

1. Flood risk is the potential for loss or harm that arises from the interaction of three factors: the hazard—the probability and intensity of flooding; exposure—the people, assets, and infrastructure in harm's way; and vulnerability—the capacity of those exposed to anticipate, cope with, and recover from floods (Nohrstedt et al. 2024).

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