KARURI MUNICIPALITY

URBAN CLIMATE RISK PROFILE

2025

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Author: Karuri Municipality
Publisher: Kiambu County
Publisher Address:

First Edition: 2025
Printed in Kenya

Disclaimer:

The Karuri Municipality Urban Climate Risk Profile (2026) is prepared solely for planning and informational purposes. The analyses, forecasts, and projections presented in this report are subject to uncertainties inherent in climate science and may change with evolving local conditions. The report is based on the data available at the time of publication.

While every effort has been made to ensure accuracy, any decisions, judgments, or actions taken based on the information herein are the sole responsibility of the user. Prior to implementing policies, investments, or interventions, users are strongly advised to consult relevant authorities, technical experts, and other appropriate specialists.

Foreword

Climate change is no longer a distant threat; it is a reality shaping daily life in Karuri Municipality. From flooded roads during the long rains to cold spells that keep children out of school, our residents are already feeling its effects. This Urban Climate Risk Profile reflects our commitment to understanding these challenges and taking timely, informed action.

Developed through inclusive processes involving municipal staff, ward administrators, community groups, and vulnerable populations, this profile highlights the hazards that threaten our people, infrastructure, and natural resources. It lays the groundwork for the Karuri Integrated Climate Risk Management Plan and will guide future adaptation and investment decisions.

I call upon all municipal departments, development partners, and citizens to use this document as a guide for planning and decision-making. Together, we can build a resilient and inclusive Karuri Municipality, ready to meet the challenges of a changing climate.

Philip Mubea ,
Manager, Karuri Municipality.
Kiambu County.

Executive Summary

This Urban Climate Risk Profile assesses the current and future climate risks facing Karuri Municipality. Three key hazards were identified through community consultations and climate data analysis: flooding, drought, and extreme cold temperatures. Using the IPCC risk framework (hazard × exposure × vulnerability), the profile evaluates risks to urban infrastructure, populations, and natural assets under current conditions and future climate scenarios (SSP2-4.5 and SSP5-8.5 for 2050 and 2100).

Key findings:

- Flooding poses very high risks to transport, stormwater drainage, and informal settlements today, and these risks will intensify significantly by 2050.
- Drought already creates high risks for water supply, agriculture, and vulnerable groups; future projections show increasing water stress.
- Extreme cold currently causes medium risks to health and education, but may slightly moderate under high-emission scenarios.

Most at risk: Informal settlement residents . elderly persons, tea pickers, and boda boda operators.

Priority actions: Upgrade stormwater drainage, expand water harvesting, implement early warning systems, and climate-proof schools and health facilities.

The summary tables below present current and projected risk levels for each hazard**.**

Table ES-1. Summary of Flood Risks for Karuri Municipality

Category	**Risk Level**				
	Current	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Infrastructure & Services					
Stormwater Drainage	High	Very High	Very High	Very high	Very high
Water & Wastewater Management	Medium	High	High	High	Very High
Solid Waste Management	Medium	High	High	High	High
Transport and Mobility	High	Very High	Very High	Very High	Very High
Energy	Low	Medium	Medium	Medium	High
Economic Infrastructure	Medium	High	High	High	Very High
Social Infrastructure	Medium	High	High	High	Very High
Emergency Services	Medium	High	High	High	Very High
Populations					
Urban Residents	High	Very High	Very High	Very High	Very High
Informal Settlement Residents	Very High	Very High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	High	Very High	Very High	Very High	Very High

Category	Risk Level				
	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Natural Assets					
Urban Green Infrastructure	Low	Medium	Medium	Medium	High
Urban Blue Infrastructure	Medium	High	High	High	Very High
Peri-urban and Agricultural Systems	Medium	High	High	High	Very High

Table ES-2. Summary of Drought risks for Karuri Municipality

Category	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Infrastructure & Services					
Stormwater Drainage	Low	Low	Low	Low	Low
Water & Wastewater Management	High	Very High	Very High	Very High	Very High
Solid Waste Management	Low	Medium	Medium	Medium	High
Transport and Mobility	Low	Medium	Medium	Medium	High
Energy	Low	Medium	Medium	Medium	High
Economic Infrastructure	Medium	High	High	High	Very High
Social Infrastructure	Medium	High	High	High	Very High
Emergency Services	Low	Medium	Medium	Medium	High
Populations					
Urban Residents	High	Very High	Very High	Very High	Very High
Informal Settlement Residents	High	Very High	Very High	Very High	Very High
Vulnerable & Marginalized Groups	Very High	Very High	Very High	Very High	Very High
Natural Assets					
Urban Green Infrastructure	Medium	High	High	High	Very High
Urban Blue Infrastructure	High	Very High	Very High	Very High	Very High
Peri-urban & Agricultural Systems	Very High	Very High	Very High	Very High	Very High

Table ES-3. Summary of Extreme Cold risks for Karuri Municipality

Category	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Infrastructure & Services					
Stormwater Drainage	Low	Low	Low	Low	Low
Water & Wastewater Management	Low	Low	Low	Low	Low
Solid Waste Management	Low	Low	Low	Low	Low
Transport and Mobility	Medium	Medium	Low	Medium	Low
Energy	Low	Low	Low	Low	Low
Economic Infrastructure	Low	Low	Low	Low	Low
Social Infrastructure	Medium	Medium	Low	Medium	Low
Emergency Services	Low	Low	Low	Low	Low
Populations					
Urban Residents	Medium	Medium	Low	Medium	Low
Informal Settlement Residents	High	High	Medium	High	Medium
Vulnerable & Marginalized Groups	High	High	Medium	High	Medium
Natural Assets					
Urban Green Infrastructure	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Low	Low	Low	Low	Low
Peri-urban & Agricultural Systems	Medium	Medium	Low	Medium	Low

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List of Acronyms

Acronym	Meaning
CCCAP	County Climate Change Action Plan
EMCA	Environmental Management and Coordination Act
FLLoCA	Financing Locally Led Climate Action
GIS	Geographic Information System
IPM	Integrated Pest Management
KEFRI	Kenya Forestry Research Institute
KFS	Kenya Forest Service
KAWASCO	Karuri Water and Sewerage Company
NEMA	National Environment Management Authority
PCRA	Participatory Climate Risk Assessment
PWD	Person with Disability
RCP	Representative Concentration Pathway
SSP	Shared Socioeconomic Pathway
WEENR	Water, Environment, Energy and Natural Resources
RCRA	Rapid Climate Risk Assessment

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1. CONTEXT

1.1. Objective

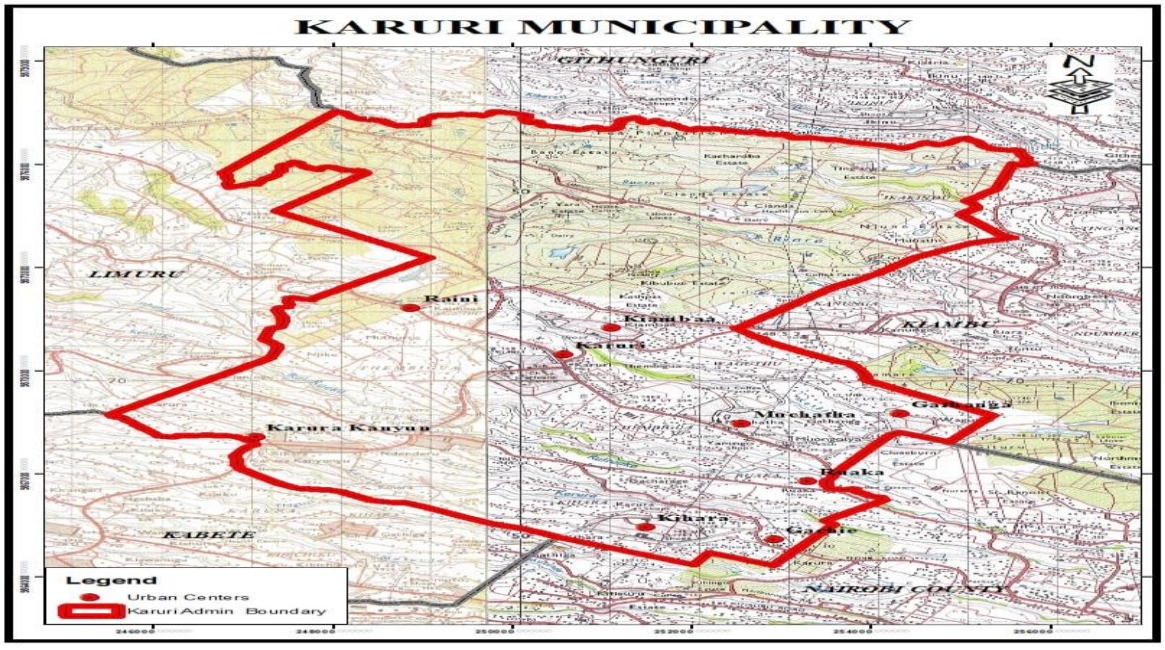
This Urban Climate Risk Profile aims to:

- Identify and prioritise the key climate hazards affecting Karuri Municipality.
- Assess the exposure, vulnerability, and impacts of these hazards on urban infrastructure, populations, and natural assets.
- Provide a robust evidence base for the Karuri ntegrated Development Plan and the County Climate Change Action Plan.
- Empower municipal decision-makers and communities with actionable risk information to guide adaptation investments under the FLLoCA programme.

1.2. Urban Context

Geographic area

Karuri Municipality in Kiambu County, Kenya covers about 46 km² and lies just north of Nairobi City County to the south, with Kabete Sub-County to the west, Limuru to the north, and Kiambu to the east. It is part of Kiambaa Constituency and has five wards: Karuri, Cianda, Ndenderu, Muchatha, and Kihara.



[Map of karuri Municipality with administrative boundaries.]

Governance Structure

Karuri Municipality is governed by a Municipal Board appointed by the Kiambu County Government, in accordance with the Urban Areas and Cities Act (2011). Key departments involved in climate resilience include:

- Municipal Manager's Office – overall coordination
- Department of Environment & Climate Change – lead for this profile
- Department of Physical Planning & Urban Development
- Department of Water & Sanitation
- Department of Roads & Public Works
- Department of Health & Public Services

The preparation of this profile was led by a Municipal Technical Working Group, with representation from all departments and community-based organisations.

Socio-economic Context

According to the 2019 Kenya Population and Housing Census, Karuri Municipality had about 236,400 people (115,500 males and 120,900 females). The population is projected to reach 279,100 by 2027, growing at 2.7% per year, driven by urbanization and proximity to Nairobi. Wards like Ndenderu, Kihara, and Muchatha are the most densely populated, highlighting the need for strategic planning of infrastructure and services.

Ward	Population (2019)	Est. Households	Area (km²)	Density (persons/km²)
Karuri	41,879	~14,441	14.5	2,898.2
Ndenderu	67,071	~23,131	15.0	4,486.4
Muchatha	53,168	~18,334	11.8	4,521.1
Kihara	53,474	~18,439	5.4	9,976.5
Cianda	20,808	~7,175	36.7	567.1
Total Municipality	**236,400**	**~81,520**	**83.2**	**2,842 (avg.)**

Source: KNBS 2019, projected using Kiambu CIDP 2023-2027

Economic Context

Karuri Municipality's economy is primarily agriculture-based, with dairy, horticulture, and small-scale crop farming as key sub-sectors. Formal employment is concentrated in tea and coffee estates, dairy cooperatives, and public administration, while many residents commute to Nairobi for work. Small-scale trade, transport (matatus and boda boda), and greenhouse farming provide supplementary livelihoods.

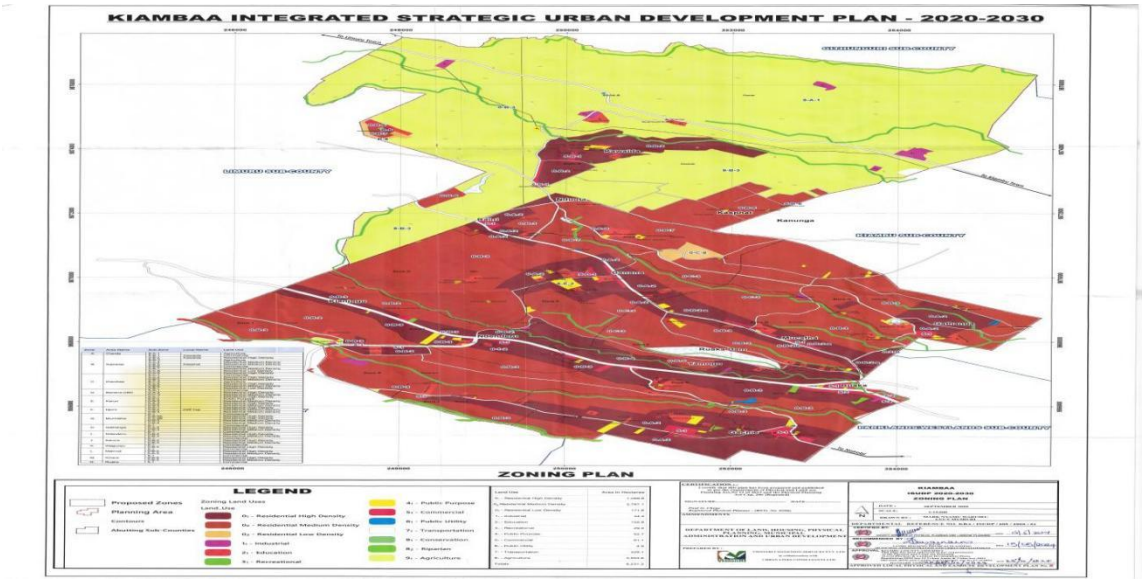
- Tea and coffee plantations cover significant portions of Ndenderu, Kihara, and Muchatha wards.
- Dairy farming (zero-grazing) is practiced across all wards, supplying cooperatives such as Karuri Dairy.
- Manufacturing and processing include tea processing, small-scale food processing, and artisanal goods.
- Youth unemployment is estimated at ~25%, with issues such as drug and substance abuse emerging during participatory consultations.
- Horticulture: Black Petals farm grows flowers and high-value crops, providing local jobs and boosting incomes

Land-use Context

Land use in Karuri Municipality is a mix of:

- Residential – high-density settlements in Ndenderu and Kihara, medium-density estates, and scattered rural homesteads in Cianda and Muchatha.
- Commercial – concentrated around Karuri town centre, local markets, banks, and retail areas.
- Agricultural – tea and coffee plantations, smallholder mixed farming, dairy, and greenhouse horticulture (e.g., Black Petals).
- Industrial – limited to tea and coffee processing, small-scale food processing, and artisanal manufacturing.
- Institutional – schools, health facilities, administrative offices, and community centers.
- Conservation – riparian reserves along rivers such as Ndenderu and Kihara, with wetlands and forest patches preserved for ecological balance.

Rapid population growth and peri-urban sprawl are converting agricultural land into residential developments, reducing pervious surfaces and increasing flood risk.



Karuri Municipality Land use map.

1.3. Key Stakeholders & Inclusiveness

Stakeholder engagement in Karuri Municipality followed the Financing Locally Led Climate Action (FLLoCA) principles. A participatory approach was applied at ward level, involving community members in hazard mapping, vulnerability assessment, and solution prioritization. Special efforts were made to include women, youth, persons with disabilities (PWDs), the elderly, and minority groups, ensuring that diverse perspectives shaped the municipality's climate risk profile and adaptation planning.

Stakeholder mapping (Influence–Interest Matrix):

	Low Interest	**High Interest**
High Influence	National government agencies (KFS, KEFRI, KMD) Kiambu County Executive	Karuri Municipal Board Ward Administrators KAWASCO Tea factory managers
Low Influence	General public (not yet organised) Private developers	Community Based Organisations (CBOs) Farmers' cooperatives Boda boda associations PWD self-help groups Youth groups

Inclusiveness measures:

- PCRA validation workshops held in accessible venues with sign language interpretation.
- Separate focus group discussions for women, youth, and PWDs.
- Use of local language (Gikuyu) during community meetings.
- Targeted outreach to informal settlement residents .

2. Hazard Assessment

Karuri Municipality experiences a bi-modal rainfall pattern (March–May long rains, October–December short rains) and a cool climate influenced by its elevation. Historical climate data (1981–2022) from the Kiambu County PCRA shows high inter-annual variability, with increasing intensity of extreme events.

2.1. Key Climate Hazards

Through the PCRA process, three hazards were prioritised by the community and validated with climate science:

Hazard	Hazard Likely (Y/N)	Significant Impact (Y/N)	High Priority (Y/N)	Key Hazard (Y/N)
Heat Stress				
Average surface temperature increase	Y	N	N	N
Extreme heat	N	N	N	N
Cold Stress				
Extreme cold (frost, cold spells)	Y	Y	Y	Y
Flooding				
Pluvial (surface) flooding	Y	Y	Y	Y
Fluvial (river) flooding	Y	Y	Y	Y
Waterlogging	Y	Y	Y	Y
Water Stress				
Drought (meteorological)	Y	Y	Y	Y
Mass Movement				
Landslides	Y (minor)	N	N	N
Gully erosion	Y	Y	Y	N (managed under flooding

Final key hazards: 1. Flooding, 2. Drought, 3. Extreme Cold

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2.2. Climate Indicators and Hazard Thresholds

Key Hazard	Climate Indicator	Data Source	Thresholds		
			Low	**Medium**	**High**
Flooding	Daily rainfall intensity (mm/day)	KMD, CORDEX-Africa	<20	20–50	>50
	River level (m) – Karura River, Nairobi River tributaries,Gitathuru, Rui-ruaka, Gatharaini.	KAWASCO, WRA	Below bank	Near bank	Over bank
Drought	Standardised Precipitation Index (SPI-12)	KMD, CHIRPS	> -0.5	-0.5 to -1.5	< -1.5
	Soil moisture percentile	ERA5-Land	>30%	15–30%	<15%
Extreme Cold	Minimum temperature (°C)	KMD, CORDEX-Africa	>8	5–8	<5
	Frost days (days with Tmin < 0°C)	KMD	0	1–3	>3

Data sources are detailed in Annex N2.

2.3. Current Hazard Levels and Climate Projections

Climate trends observed across Kenya indicate increasing climate variability, characterized by changes in rainfall patterns, more frequent extreme weather events, and rising temperatures. According to climate data available through the World Bank Climate Change Knowledge Portal, Kenya has experienced gradual increases in average temperatures over recent decades, alongside increasing variability in seasonal rainfall.

Rainfall patterns in central Kenya, including Kiambu County, are typically characterized by two rainy seasons: the long rains occurring between March and May and the short rains between October and December. However, these seasonal patterns have become less predictable in recent years. Periods of intense rainfall have occasionally resulted in localized

flooding in urban and peri-urban areas, particularly where drainage systems are insufficient to accommodate heavy runoff.

At the same time, extended dry periods have also been observed between rainy seasons. These conditions can contribute to water stress, particularly in areas that rely on rainfall for agriculture or where water supply infrastructure is limited.

Climate projections for East Africa suggest that temperatures are likely to continue increasing over the coming decades. Higher temperatures may contribute to increased evaporation rates and heat stress in urban areas, particularly in densely built environments with limited vegetation cover.

Future climate projections also indicate that rainfall events may become more intense even if overall annual rainfall totals do not change significantly. This trend could increase the likelihood of urban flooding in municipalities such as Kikuyu where rapid urban development and increased impervious surfaces reduce natural infiltration and increase stormwater runoff.

Future projections are derived from the Kiambu County PCRA, which downscaled CMIP5 models under RCP4.5 and RCP8.5 (equivalent to SSP2-4.5 and SSP5-8.5). For karuri :

- **Flooding**: Historical trends show increased frequency of high-intensity rainfall during MAM and OND. Projections indicate a wet signal for annual rainfall (+5–10% by 2050) under both scenarios, but with greater temporal compression – more rain in fewer days. This increases pluvial and fluvial flood hazard.
- **Drought**: MAM rainfall is projected to decrease by 10–20% under RCP8.5 by 2050, while OND rainfall remains variable. Increased evaporative demand due to warming will exacerbate agricultural drought.
- **Extreme Cold**: Minimum temperatures are projected to rise by 0.8–1.5°C by 2050, reducing the frequency of frost. However, cold spells will still occur, particularly in higher areas kihara ward .

Hazard	Current (Baseline)	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Flooding	High	High	Very High	High	Very High
Drought	Medium	High	Very High	High	Very High
Extreme Cold	Medium	Medium	Low	Medium	Low

For this Urban Climate Risk Profile, hazard levels should be interpreted in accordance with the table below.

Interpretation of hazard levels:

Level	Interpretation
Very High	Hazard events are likely to occur with very high frequency and/or intensity; extreme events may become the new normal.
High	Hazard events occur frequently; moderate to severe intensity.
Medium	Hazard events occur occasionally; moderate intensity.
Low	Hazard events are rare and/or mild.

Understanding these trends is important for planning climate adaptation measures that address both current and future climate risks affecting the municipality.

Historical Climate Hazard Events

Historical hazard events provide important insight into the types of climate impacts that have already affected Karuri Municipality and surrounding areas. Observed flooding events in the Nairobi metropolitan region and Kiambu County demonstrate the potential impacts of intense rainfall on infrastructure, housing, and mobility.

Flooding has been reported in various parts of the Nairobi metropolitan region during periods of heavy rainfall, affecting transport networks, residential areas, and drainage systems. Similar localized flooding events have been observed within Karuri Municipality, particularly in areas with limited drainage capacity or where development has occurred near waterways and wetlands.

Table 1: Selected Historical Climate Hazard Events affecting Karuri.

Year	Hazard Event	Observed Impacts
2016–2017	Drought and Water Shortages – Gacharage and Muchatha areas	Below-average rainfall led to reduced water levels in streams and boreholes, affecting domestic water supply and small-scale farming activities in peri-urban areas.
2017	Soil erosion and localized landslides in hilly areas (Gacharage and Banana highlands)	Heavy rains on steep slopes caused soil erosion and damage to farms and rural access roads. Agricultural productivity was affected in some areas.
2018	Heavy rainfall and localized flooding in Muchatha, Banana and Ruaka areas	Blocked drainage systems and rapid urban development caused flooding of roads, residential areas and businesses during intense rainfall events.
2020	Intense rainfall during the long rains season	Flooding occurred in low-lying sections and along drainage channels, disrupting transport and increasing runoff in urban areas.
2022	Periods of below-average rainfall	Water shortages were experienced in parts of Karuri Municipality as reduced rainfall affected water supply systems and agricultural activities.
2024	Heavy rainfall and flood risk across Kiambu County including Karuri	Rising water levels and flooding affected infrastructure and settlements, prompting warnings for residents near water bodies to relocate to safer areas.

2.3.2 Future Climate Projections

Climate projections for Kenya indicate a continued increase in temperature and greater variability in rainfall patterns over the coming decades. According to projections from the World Bank Climate Change Knowledge Portal, mean annual temperatures in Kenya are expected to increase by approximately 1.5–2.5°C by the 2050s under intermediate emissions scenarios. In addition, rainfall patterns are expected to become more erratic, with an increase in the intensity of extreme rainfall events. These changes are likely to increase the risk of flooding, landslides, and water stress in rapidly urbanizing municipalities such as karuri

2.4. Current and Future Hazard Impact Areas

The impacts of climate hazards are not evenly distributed across the municipality. Certain locations may be more exposed to specific hazards due to environmental conditions, land-use patterns, and infrastructure limitations.

Hazard	Current Impact Areas	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Drought / Water Stress	Gacharage, Nderu, and peri-urban farming zones around Banana where households rely on rain-fed agriculture and small water sources	Moderate increase in soil moisture stress; higher pressure on water supply systems	Greater rainfall variability; higher drought intensity and increased household water demand	Regular seasonal drought affecting agriculture and water supply reliability	Persistent drought conditions; water rationing likely; shift toward drought-resistant crops and improved water storage
Extreme Heat / Urban Heat	Ruaka town centre, Muchatha, Banana trading centres, dense residential estates and major transport corridors with limited tree cover	Expansion of warmer urban zones; warmer nights and reduced cooling periods	Higher frequency of hot days and heat stress especially in built-up areas	Municipality-wide temperature increase; heat exposure increases for vulnerable populations	Frequent extreme heat conditions; increased health risks, energy demand for cooling, and reduced outdoor productivity
Flooding / Intense Rainfall	Low-lying areas near rivers and drainage channels in Ruaka, Muchatha and parts of Banana where rapid urbanisation has reduced natural drainage	Increased frequency of intense rainfall events causing localized flooding and drainage overflow	Higher rainfall intensity causing flash floods and infrastructure damage	Larger flood-prone zones along rivers and urban drainage channels	Severe flood events affecting roads, settlements and businesses; greater disruption of transport networks
Soil Erosion / Landslides	Hilly areas around Gacharage and slopes toward Limuru highlands where steep terrain and farming occur	More frequent minor slope failures and soil erosion during heavy rains	Increased slope instability and small landslides during extreme rainfall	Expanded erosion-prone areas affecting farms and rural roads	High-risk slope zones expand with potential major landslides affecting infrastructure and settlements

Flooding:
Currently affects Muchatha (low-lying residential and commercial areas with limited stormwater drainage), Cianda (sections along local streams and poorly drained roads), and parts of Ndenderu where runoff from upper slopes accumulates. Flooding often leads to waterlogging of roads, disruption of local businesses, and damage to homes during heavy rainfall events. In the future, flood-prone areas are expected to expand along river corridors such as the Nderu and Ruaka river systems due to increased rainfall intensity, urban expansion, and encroachment into riparian zones.

Drought:
Drought impacts are most pronounced in Ndenderu and Cianda wards, where many households rely on boreholes, shallow wells, and rain-fed agriculture. Water stress already occurs during the dry seasons (January–February and July–September), affecting domestic water supply and smallholder farming. Under high-emissions climate scenarios (SSP5-8.5 / RCP8.5), water demand is expected to increase while rainfall variability intensifies, leading to greater seasonal water shortages and pressure on groundwater resources by 2050.

Extreme Cold:
Extreme cold and frost events are most common in Kihara ward, particularly in high-altitude areas with tea farms and exposed settlements. Frost currently occurs occasionally during the June–August cold season, affecting agricultural productivity and vulnerable populations living in poorly insulated housing. Climate projections suggest that the frequency of frost events may gradually decline by 2100 due to overall warming, although occasional cold spells may still occur and continue to affect crops and livelihoods.

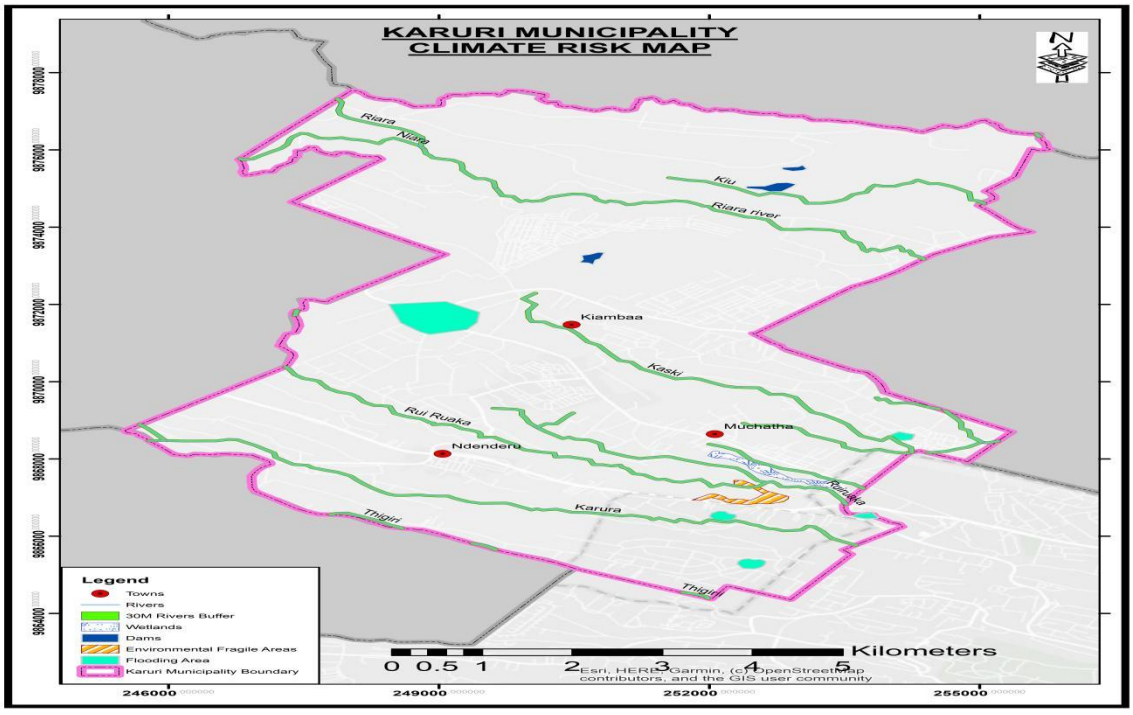

Figure 3:climate risk hotspots karuri

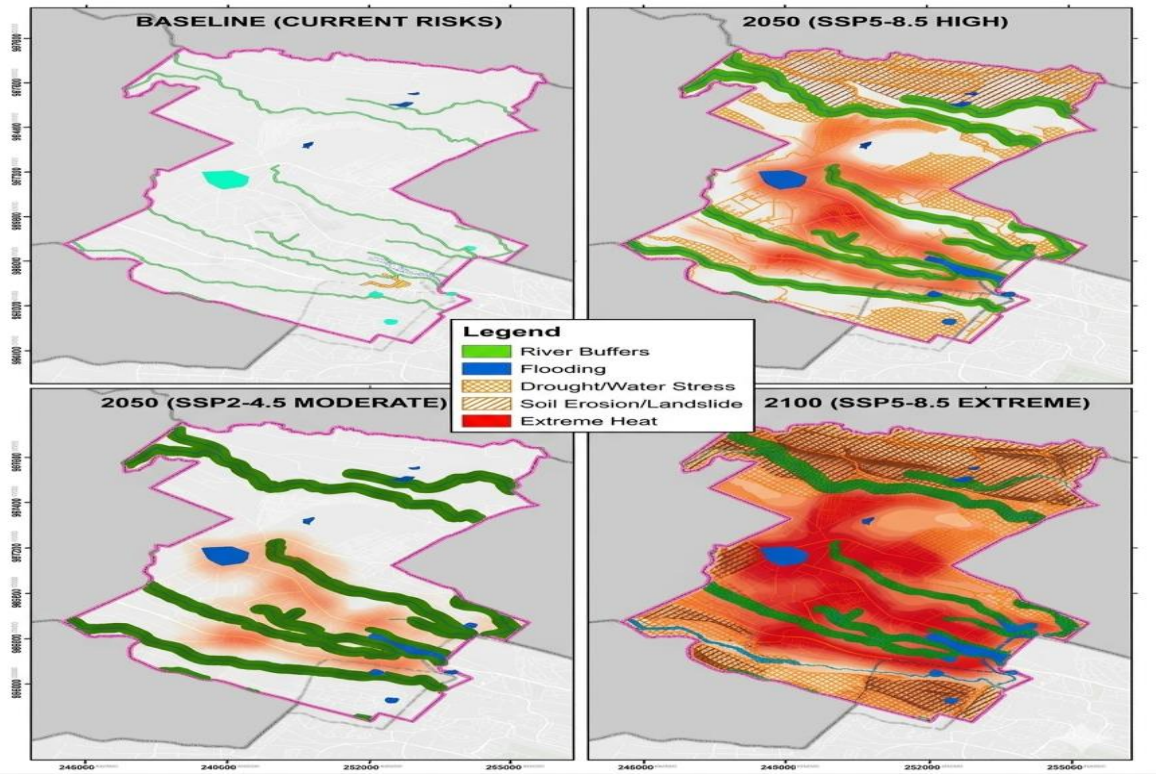

Figure 4:Maps showing hazard extents under current and future scenarios karuri

3.Exposure & Vulnerability Assessment.

3.1 Urban Elements

Table 1. Urban elements inventory

Category	Subcategory	Included in RCRA (Y/N)	Available in GIS (Y/N)	Description
Infrastructure & Services				
Stormwater Drainage	Stormwater conveyance network	Y	N (partial)	Roadside drainage channels and culverts along Kiambu Road, Banana–Ruaka Road and internal town roads; inadequate drainage in rapidly urbanising estates such as Ruaka, Ndenderu and Muchatha.
	Stormwater storage	N	N	No formal stormwater retention systems; Seasonal streams provide limited natural drainage.
Water & Wastewater Management	Pumping stations	Y	N (partial)	Borehole pumping systems and water pumping facilities operated by Karuri Water & Sanitation Company.
	Groundwater abstraction	Y	N	Approximately 9–12 boreholes supply water to the municipality and community water projects. (Karuri Water)
	Water treatment facilities	Y	N	No major treatment plant in Karuri; water is mainly supplied through boreholes and bulk supply from Sasumua transmission mains via Nairobi City Water. (Karuri Water)
	Water supply networks	Y	Y	Piped water network operated by Karuri Water & Sanitation Company serving approximately 70% of the population. (Karuri Water)
	Sewer networks	Y (planned)	N	Sewer system currently under development; most households rely on septic tanks and pit latrines. (Karuri Water)
	Wastewater treatment facilities	N	N	No operational municipal WWTP within Karuri; wastewater managed through on-site sanitation.
Solid Waste Management	Transfer facilities	Y	N	Waste collected by Kiambu County trucks and private collectors and transported to county disposal sites.
	Landfills and dump sites	Y	N	Waste disposed mainly at county dumpsites such as Kangoki dumpsite outside the municipality.
	Recycling centres	N	N	Recycling mainly undertaken informally by waste pickers and small

Category	Subcategory	Included in RCRA (Y/N)	Available in GIS (Y/N)	Description
				private recyclers.
	Collection fleet	Y	Y	Kiambu County solid waste trucks supported by private waste collectors operating in estates and commercial areas.
Transport & Mobility	Road networks	Y	Y	Major roads include Kiambu–Ruaka Road, Banana–Limuru Road and internal urban roads linking Ndenderu, Cianda, Muchatha and Kihara; many feeder roads remain murram.
	Bridges	Y	N	Small bridges and culverts along river crossings in Ndenderu and Cianda areas.
	Public transport networks	Y	N	Matatu and boda boda services connecting Karuri to Nairobi, Kiambu Town, Limuru and Ruaka.
	Transportation terminals	Y	Y	Banana town matatu stage and Ruaka transport hubs.
	Non-motorised transport	N (limited)	N	Limited pedestrian walkways; cycling infrastructure largely absent.
Energy	Poles and power lines	Y	Y	Kenya Power electricity distribution network serving residential estates and commercial areas.
	Transformers and substations	Y	Y	Multiple transformers located across estates such as Ndenderu, Banana and Muchatha.
	Street lighting	Y	Y	Solar and grid-powered streetlights installed along major roads and trading centres.
Economic Infrastructure	Markets	Y	Y	Karuri Market, Banana Market and Ndenderu Market serve local traders and farmers.
	Businesses & commercial hubs	Y	N	Growing commercial centres in Banana, Ruaka and Ndenderu with retail shops, malls, hotels and service enterprises.
	Industrial zones	N	N	No large industrial zones; economy dominated by retail, hospitality, services and construction.
Social Infrastructure	Government buildings	Y	Y	Karuri Municipal offices and ward administrative offices.
	Education facilities	Y	Y	Numerous ECDE centres, primary and secondary schools, and institutions such as Karuri KMTC campus.
	Healthcare facilities	Y	Y	Karuri Level 4 Hospital, private hospitals and dispensaries serving the

Category	Subcategory	Included in RCRA (Y/N)	Available in GIS (Y/N)	Description
				municipality.
	Public spaces	Y	N	Small public open spaces, playgrounds and church compounds used as community gathering areas.
	Faith-based buildings	N	N	Numerous churches and religious institutions across all wards.
Emergency Services	Fire stations	Y	Y	One fire station located in Banana serving Karuri Municipality.
	Police stations	Y	Y	Karuri Police Station and several police posts serving surrounding wards.
	Early warning systems	N	N	No formal disaster early warning system at municipal level.
	Disaster management centres	N	N	Disaster response coordinated at Kiambu County level.
Populations				
Urban Residents	Population	Y	Y	Karuri Municipality population estimated at about 194,000 (2019 census).
	Households	Y	N	Approximately 50,000 households estimated across the municipality.
Informal Settlement Residents	Population in informal settlements	Y	N	Informal settlements exist in parts of Ruaka, Ndenderu and Muchatha.
	Households lacking land tenure	Y	N	Informal residents with insecure tenure in rapidly urbanizing peri-urban settlements.
	Households lacking basic services	Y	N	Limited sewerage, drainage and waste collection services in informal areas.
Vulnerable & Marginalized Groups	Low-income households	Y	N	Significant proportion of households working in informal employment and service sector.
	Women-headed households	Y	N	Common in both formal estates and informal settlements.
	Children and youth	Y	Y	Youth constitute a large share of population due to proximity to Nairobi employment centres.
	Elderly persons	Y	N	Smaller but growing share of population.
	People with disabilities	Y	N	Limited data; services mainly provided through health facilities and NGOs.
	Unemployed youth	Y	N	Youth unemployment present despite proximity to Nairobi job market.

Category	Subcategory	Included in RCRA (Y/N)	Available in GIS (Y/N)	Description
	Seasonal workers	Y	N	Construction workers, domestic workers and service sector labour.
Natural Assets				
Urban Green Infrastructure	Urban parks and gardens	Y	N	Few formal parks; greenery mostly within private compounds and schools.
	Green corridors	N	N	No formally designated ecological corridors.
	Urban forests	Y	N	Scattered trees and small woodlots in peri-urban areas.
Urban Blue Infrastructure	Natural wetlands	Y	N	Small wetlands and seasonal drainage areas in Ndenderu and Cianda.
	Rivers	Y	Y	Rivers including Gatharaini and its tributaries flowing towards Nairobi River basin.
	Riparian zones	Y	N	Some encroachment from residential development.
	Lakes/ponds	Y	N	Small farm dams and ponds used for irrigation and livestock.
Peri-urban & Agricultural Systems	Peri-urban agriculture	Y	N	Dairy farming, vegetables and horticulture in peri-urban zones such as Kihara and Cianda.
	Agroforestry	Y	N	Mixed farming systems with fruit trees and timber species.
	Forests and reserves	Y	Y	Karura Forest located south of the municipality forms a key ecological asset.

3.2 Exposure, Vulnerability, and Impacts of Climate Hazards on Urban Elements

For this Urban Climate Risk Profile, exposure and vulnerability levels should be interpreted in accordance with the table below.

Table 3. Interpretation of exposure and vulnerability levels

Level	Exposure Level Interpretation	Vulnerability Level Interpretation
High	A large number and high-value urban elements are located within the hazard footprint.	The urban element is vulnerable to the hazard due to high sensitivity and limited adaptive capacity.
Medium	A moderate number or mix of low- and medium-value elements are located within the hazard footprint.	The element is somewhat vulnerable due to moderate sensitivity and adaptive capacity
Low	Few or no critical urban elements lie within the hazard footprint.	The element is minimally vulnerable due to limited sensitivity and/or high adaptive capacity.

For this Urban Climate Risk Profile, the following matrix summarizes likely impacts on each urban element by combining the assigned exposure and vulnerability levels.

Table 4. Impact Matrix

		Vulnerability Level		
		Low	**Medium**	**High**
Exposure Level	**High**	Moderate	Major	Catastrophic
	Medium	Minor	Moderate	Major
	Low	Insignificant	Minor	Moderate

Table 5. Exposure, Vulnerability, and Impacts of Flooding on Urban Elements
Hazard: Flooding.

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure & Services					
Stormwater Drainage	Drainage channels in Banana, Ndenderu and Ruaka frequently overflow during heavy rainfall. Rapid urbanisation has increased impervious surfaces, causing runoff to exceed drainage capacity.	High	**Sensitivity:** Inadequate and undersized drainage, blocked by solid waste; limited stormwater planning in rapidly urbanising estates. **Adaptive Capacity:** Low – drainage infrastructure incomplete and maintenance irregular.	High	Catastrophic
Water & Wastewater Management	Municipal water supply relies on boreholes and pumping stations which may experience flooding or contamination during extreme rainfall. Most households rely on septic systems that can overflow during floods.	Medium	**Sensitivity:** On-site sanitation vulnerable to groundwater contamination; pumping equipment exposed. **Adaptive Capacity:** Medium – water utility provides repairs but infrastructure redundancy is limited.	Medium	Major
Solid Waste Management	Waste collection points in Banana, Ruaka and Ndenderu often experience overflow during storms, with waste washed into drainage channels and rivers.	High	**Sensitivity:** Informal dumping and poor drainage management cause blockages. **Adaptive Capacity:** Low – limited formal recycling systems and irregular waste collection in some areas.	High	Catastrophic
Transport & Mobility	Flooding occasionally affects sections of the Banana–Ruaka Road, Kiambu–Ruaka Road and feeder roads in Ndenderu and Muchatha, disrupting transport and local commerce.	Medium	**Sensitivity:** Many feeder roads are murram and easily eroded; culverts often undersized. **Adaptive Capacity:** Medium – road repairs undertaken by county government but often reactive.	Medium	Major
Energy	Power distribution infrastructure in residential areas is vulnerable to storm damage, falling trees and lightning.	Medium	**Sensitivity:** Overhead distribution lines susceptible to strong winds and storms. **Adaptive Capacity:** Medium – Kenya Power restores services but outages may last several hours.	Medium	Moderate
Economic Infrastructure	Markets and commercial centres in Banana and Ndenderu experience localized flooding during heavy rainfall, affecting small businesses and informal	Medium	**Sensitivity:** Poor drainage around markets and roadside stalls. **Adaptive Capacity:** Low – limited flood-proofing and limited financial resilience among small	Medium	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
	traders.		traders.		
Social Infrastructure	Some schools, health centres and community facilities in peri-urban areas experience poor drainage and access issues during heavy rainfall events.	Medium	**Sensitivity:** Many institutions lack flood-resilient infrastructure and adequate drainage. **Adaptive Capacity:** Medium – county government undertakes repairs but retrofitting is limited.	Medium	Major
Emergency Services	Emergency response services depend on county-level facilities and road accessibility which may be disrupted during extreme weather events.	Medium	**Sensitivity:** Limited local disaster response infrastructure. **Adaptive Capacity:** Low – lack of local disaster management centre and early warning systems.	Medium	Major
Populations					
Urban Residents	Rapid population growth and urban expansion increase exposure to flooding and infrastructure stress in estates such as Ruaka, Banana and Muchatha.	High	**Sensitivity:** High housing density and informal developments increase exposure. **Adaptive Capacity:** Medium – better access to services than rural areas but infrastructure lagging behind growth.	High	Major
Informal Settlement Residents	Informal settlements in Ruaka and Ndenderu are located near drainage channels and river valleys, increasing exposure to flooding and poor sanitation.	High	**Sensitivity:** Poor housing materials, lack of drainage and sanitation infrastructure. **Adaptive Capacity:** Very low – limited land tenure and limited access to financial resources.	High	Catastrophic
Vulnerable & Marginalised Groups	Elderly persons, children, and people with disabilities face increased risk during flooding or extreme weather events due to mobility and health limitations.	High	**Sensitivity:** Reduced mobility and higher health risks during disasters. **Adaptive Capacity:** Low – limited targeted social protection programmes.	High	Catastrophic
Natural Assets					
Urban Green Infrastructure	Urban vegetation and small green spaces may experience degradation due to urban expansion and extreme rainfall events.	Medium	**Sensitivity:** Loss of vegetation reduces natural flood mitigation capacity. **Adaptive Capacity:** Medium – tree planting initiatives exist but coverage is limited.	Medium	Moderate
Urban Blue Infrastructure	Rivers and drainage channels such as the Gatharaini River system receive runoff and waste from urban areas, increasing flood and pollution risk.	High	**Sensitivity:** Encroachment and poor riparian protection increase vulnerability. **Adaptive Capacity:** Low – limited enforcement of riparian protection regulations.	High	Catastrophic
Peri-urban & Agricultural	Dairy farming and horticulture in peri-urban areas such as Cianda and Kihara may be affected by	Medium	**Sensitivity:** Smallholder farmers rely on rain-fed agriculture. **Adaptive Capacity:** Medium – some	Medium	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Systems	extreme rainfall, soil erosion and water scarcity during dry periods.		farmers use soil conservation practices.		

Table 6. Exposure, Vulnerability, and Impacts of Drought on Urban Elements
Hazard: Drought

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure & Services					
Water & Wastewater Management	Karuri Municipality relies largely on boreholes and limited bulk water supply. During prolonged dry periods, boreholes in areas such as Cianda, Kihara and Ndenderu experience reduced yields, leading to water rationing in Banana and surrounding estates.	High	**Sensitivity:** Heavy reliance on groundwater sources; growing population increasing demand; high non-revenue water losses. **Adaptive Capacity:** Low – limited municipal storage reservoirs and insufficient rainwater harvesting systems.	High	Catastrophic
Solid Waste Management	Dry conditions increase the risk of fires at informal waste dumping sites and collection points.	Low	**Sensitivity:** Waste accumulation at collection points may become combustible during prolonged dry conditions. **Adaptive Capacity:** Low – limited fire prevention and monitoring systems at waste sites.	Medium	Minor
Energy	Electricity supply in Karuri is mainly grid-based and less directly affected by drought, though hydropower variability may influence national generation.	Low	**Sensitivity:** Local energy infrastructure not directly dependent on local water sources. **Adaptive Capacity:** High – diversified national energy supply and increasing solar adoption.	Low	Insignificant
Economic Infrastructure	Small businesses and markets in Banana, Ruaka and Ndenderu experience reduced availability of	Medium	**Sensitivity:** Markets depend on agricultural supply from Kiambu and neighbouring	Medium	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
	agricultural produce during drought, leading to higher food prices and reduced trade volumes.		counties. **Adaptive Capacity:** Medium – traders may source produce from other regions but at higher cost.		
Social Infrastructure	Schools and health facilities experience water shortages during drought periods, affecting sanitation and daily operations.	Medium	**Sensitivity:** Limited water storage capacity in institutions; increased sanitation risks. **Adaptive Capacity:** Low – reliance on water trucking during shortages.	High	Major
Emergency Services	Fire response services may face challenges due to limited water availability for firefighting during drought periods.	Medium	**Sensitivity:** Fire hydrants and local water sources may have reduced supply. **Adaptive Capacity:** Low – limited dedicated emergency water storage systems.	High	Major
Populations					
Urban Residents	Many residents depend on piped water supplied from boreholes; during drought periods rationing increases and residents rely on water vendors.	High	**Sensitivity:** High water demand due to population growth and urban development. **Adaptive Capacity:** Low – limited household water storage and rainwater harvesting systems.	High	Catastrophic
Informal Settlement Residents	Informal settlements in Ruaka, Ndenderu and parts of Muchatha rely heavily on water vendors whose prices increase during drought periods.	High	**Sensitivity:** Limited access to piped water and sanitation infrastructure. **Adaptive Capacity:** Very low – low household income and limited storage facilities.	High	Catastrophic
Vulnerable & Marginalised Groups	Elderly persons, children and low-income households are disproportionately affected by water scarcity and rising food prices during drought periods.	High	**Sensitivity:** Increased health risks due to poor sanitation and reduced nutrition. **Adaptive Capacity:** Low – limited social safety nets and alternative livelihoods.	High	Catastrophic
Natural Assets					
Urban Green	Urban vegetation, roadside trees and small green	Medium	**Sensitivity:** Many ornamental species not	High	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure	spaces experience water stress and decline during prolonged dry conditions.		drought tolerant. **Adaptive Capacity:** Low – limited irrigation systems for public green spaces.		
Urban Blue Infrastructure	Reduced river flows in the Gatharaini River system and other tributaries affect aquatic ecosystems and water availability.	High	**Sensitivity:** Increased abstraction and pollution pressure during drought. **Adaptive Capacity:** Low – limited catchment protection and environmental flow regulation.	High	Catastrophic
Peri-urban & Agricultural Systems	Smallholder farmers in Cianda, Kihara and peri-urban areas depend on rain-fed agriculture and livestock production, which are highly vulnerable to drought.	High	**Sensitivity:** Crop failure and reduced pasture for dairy farming. **Adaptive Capacity:** Low – limited irrigation infrastructure and drought-resilient farming practices.	High	Catastrophic

Table 7. Exposure, Vulnerability, and Impacts of Extreme Cold on Urban Elements

Hazard: Extreme Cold

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure & Services					
Transport & Mobility	Cold season fog occasionally affects visibility along Kiambu–Ruaka Road and Banana–Limuru Road, increasing accident risk during early mornings.	Medium	**Sensitivity:** Roads pass through elevated areas with occasional fog; limited road signage and lighting in some sections. **Adaptive Capacity:** Low – limited warning systems and traffic management during fog events.	Medium	Major
Energy	Increased electricity demand during cold periods due to heating needs and hot water use in households.	Low	**Sensitivity:** Power infrastructure generally resilient to cold conditions. **Adaptive Capacity:** Medium – Kenya Power responds quickly to outages.	Low	Minor
Social Infrastructure	Schools and ECDE centres may experience cold classrooms during early mornings in the June–August season.	Medium	**Sensitivity:** Many classrooms lack insulation or heating systems. **Adaptive Capacity:** Low – schools rely on warm clothing rather than building improvements.	Medium	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Emergency Services	Health facilities occasionally receive patients with cold-related respiratory illnesses during cold seasons.	Low	**Sensitivity:** Young children and elderly patients more susceptible to cold-related illnesses. **Adaptive Capacity:** Medium – health facilities provide treatment but preventive programs are limited.	Low	Minor
Populations					
Urban Residents	Residents experience cold nights during the June–August cold season, particularly in peri-urban areas with open housing structures.	Medium	**Sensitivity:** Houses with poor insulation increase exposure to cold conditions. **Adaptive Capacity:** Medium – households use warm clothing and charcoal stoves for heating.	Medium	Major
Informal Settlement Residents	Informal settlements in areas such as Ndenderu and Ruaka have housing made from temporary materials that provide little protection from cold weather.	High	**Sensitivity:** Poor housing materials, overcrowding and lack of bedding increase vulnerability. **Adaptive Capacity:** Very low – limited financial resources for adequate clothing or bedding.	High	Catastrophic
Vulnerable & Marginalised Groups	Elderly persons, young children and people with chronic respiratory conditions are most affected during cold seasons.	High	**Sensitivity:** Higher risk of respiratory infections and health complications. **Adaptive Capacity:** Low – limited targeted support programs.	High	Catastrophic
Natural Assets					
Urban Green Infrastructure	Cold conditions may affect growth of ornamental plants and urban vegetation during cold months.	Low	**Sensitivity:** Some plant species are not tolerant to cooler temperatures. **Adaptive Capacity:** Medium – replacement planting often occurs.	Low	Minor
Peri-urban & Agricultural Systems	Cold temperatures may slow crop growth for vegetables and horticulture in peri-urban farms around Cianda and Kihara.	Medium	**Sensitivity:** Some crops sensitive to prolonged cold conditions. **Adaptive Capacity:** Medium – farmers adjust planting periods and crop varieties.	Medium	Major

Table 4.4. Exposure, Vulnerability, and Impacts of Landslides on Urban Elements

Hazard: Landslides / Mass Movement

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure & Services					
Transport & Mobility	Roads along slopes and river valleys in areas such as Ndenderu, Kihara and Cianda may experience soil erosion and minor slope failures during heavy rainfall, affecting road stability.	Medium	**Sensitivity:** Road cuts often unengineered; inadequate slope drainage; soil erosion during storms. **Adaptive Capacity:** Low – slope stabilization and drainage improvements are limited; maintenance mostly reactive.	Medium	Major
Water & Wastewater Management	Water pipelines and borehole infrastructure located near slopes and river valleys may be damaged by soil movement or erosion during heavy rains.	Medium	**Sensitivity:** Pipelines vulnerable to soil displacement and erosion in unstable areas. **Adaptive Capacity:** Medium – repairs undertaken by water utility but preventive slope protection is limited.	Medium	Major
Energy	Electricity poles and overhead lines located on unstable slopes may be affected by soil erosion or falling trees during storms.	Medium	**Sensitivity:** Wooden power poles with shallow foundations vulnerable to soil movement. **Adaptive Capacity:** Medium – utility companies repair outages but limited preventive relocation.	Medium	Moderate
Social Infrastructure	Some schools, health facilities and residential buildings located near riverbanks or slopes may experience foundation instability due to soil erosion.	Medium	**Sensitivity:** Limited geotechnical assessment before construction in some developments. **Adaptive Capacity:** Low – slope protection measures such as retaining walls rarely implemented.	Medium	Major
Emergency Services	Access to certain neighbourhoods may be disrupted if slope failures block roads or drainage channels.	Medium	**Sensitivity:** Some areas rely on single access roads. **Adaptive Capacity:** Low – no specialised landslide monitoring or early warning systems.	Medium	Major
Populations					
Urban Residents	Residents living along river valleys and sloping	Medium	**Sensitivity:** Rapid construction on slopes without proper	Medium	Major

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
	terrain may face risks from soil erosion and localized slope instability during extreme rainfall.		drainage or retaining structures. **Adaptive Capacity:** Medium – households may undertake minor slope stabilization but resources limited.		
Informal Settlement Residents	Informal housing in areas such as Ndenderu and Ruaka may be constructed on marginal land near drainage channels or unstable slopes.	High	**Sensitivity:** Poor construction materials and lack of slope drainage. **Adaptive Capacity:** Very low – limited financial capacity to implement stabilization measures.	High	Catastrophic
Vulnerable & Marginalised Groups	Elderly persons, children and people with disabilities may face greater risks during slope failures due to limited mobility and evacuation capacity.	High	**Sensitivity:** Physical mobility constraints and limited disaster awareness. **Adaptive Capacity:** Very low – limited targeted emergency support systems.	High	Catastrophic
Natural Assets					
Urban Green Infrastructure	Vegetation and tree cover along slopes provide some stabilization but may be reduced due to urban development and land clearing.	Medium	**Sensitivity:** Loss of vegetation increases erosion and slope instability. **Adaptive Capacity:** Medium – community tree planting and environmental protection initiatives exist but coverage limited.	Medium	Moderate
Peri-urban & Agricultural Systems	Farming on sloping land in Cianda and Kihara may lead to soil erosion during heavy rains if conservation measures are inadequate.	Medium	**Sensitivity:** Cultivation on slopes without terracing or erosion control. **Adaptive Capacity:** Medium – some farmers practice soil conservation but adoption uneven.	Medium	Major

Table 5.4. Exposure, Vulnerability, and Impacts of Strong Winds on Urban Elements

Hazard: Strong Winds / Storms

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Infrastructure & Services					
Energy	Overhead electricity lines across the municipality are vulnerable to strong winds and falling trees during storms, particularly in residential estates with mature roadside trees.	High	**Sensitivity:** Wooden poles and overhead distribution lines exposed to wind and falling branches. **Adaptive Capacity:** Medium – Kenya Power repairs outages but preventive vegetation management is limited.	Medium	Major
Transport & Mobility	Strong winds and storms occasionally cause trees and debris to block roads in areas such as Banana, Ndenderu and Ruaka, disrupting transport and increasing accident risk.	Medium	**Sensitivity:** Roadsides lack protective windbreaks; limited stormwater drainage causes debris accumulation. **Adaptive Capacity:** Low – road clearance mainly reactive after events.	Medium	Major
Social Infrastructure	School buildings, ECDE centres and health facilities with lightweight roofing may experience roof damage during strong wind events.	Medium	**Sensitivity:** Corrugated iron sheet roofing common in many public facilities. **Adaptive Capacity:** Low – limited structural reinforcement and building maintenance budgets.	Medium	Major
Economic Infrastructure	Market stalls and informal roadside businesses in Banana and Ndenderu may be damaged by strong winds or heavy storms.	Medium	**Sensitivity:** Many stalls made from lightweight materials and temporary structures. **Adaptive Capacity:** Low – traders have limited resources to reinforce structures.	Medium	Major
Emergency Services	Storm events may increase emergency response calls and obstruct access routes due to fallen trees and debris.	Medium	**Sensitivity:** Some neighbourhoods rely on limited access roads. **Adaptive Capacity:** Low – emergency services rely on county-level resources and equipment.	Medium	Major
Populations					
Urban Residents	Strong winds may damage roofs and property, particularly in rapidly developing residential areas where construction standards vary.	Medium	**Sensitivity:** Roofing materials and construction quality vary widely. **Adaptive Capacity:** Medium – households may undertake repairs but insurance coverage is limited.	Medium	Major
Informal	Informal housing in areas such as Ndenderu and	High	**Sensitivity:** Temporary building materials and poor	High	Catastrophic

Category	Exposure (Description)	Exposure Level	Vulnerability (Sensitivity / Adaptive Capacity)	Vulnerability Level	Impact Level
Settlement Residents	Ruaka may be severely affected by storms due to weak structures and overcrowding.		structural stability. **Adaptive Capacity:** Very low – limited resources for repairs or relocation.		
Vulnerable & Marginalised Groups	Outdoor workers such as boda boda riders, street vendors and school children travelling during storms face increased risk of injury.	High	**Sensitivity:** High exposure due to outdoor activities and limited protective infrastructure. **Adaptive Capacity:** Very low – limited safety equipment or shelter options.	High	Catastrophic
Natural Assets					
Urban Green Infrastructure	Strong winds may uproot trees and damage vegetation in urban spaces and along roadsides.	Medium	**Sensitivity:** Some tree species have shallow roots and are vulnerable to wind damage. **Adaptive Capacity:** Medium – tree replanting and maintenance programs exist but coverage limited.	Medium	Major
Peri-urban & Agricultural Systems	Strong winds and storms may damage crops and horticulture in peri-urban farms around Cianda and Kihara.	Medium	**Sensitivity:** Crops exposed to wind damage and soil erosion during storms. **Adaptive Capacity:** Medium – farmers may use windbreaks but adoption remains limited.	Medium	Major

4.Climate Risk Assessment.

For this Urban Climate Risk Profile, the following matrix summarizes overall risk for each urban element by combining the assessed hazard level and the estimated impact level.

Table 8. Risk matrix

		Hazard Level		
		Low	**Medium**	**High**
Impact Level	**Catastrophic**	High	Very High	Very High
	Major	Medium	High	Very High
	Moderate	Low	Medium	High
	Minow	Low	Low	Medium
	Insignificant	Very Low	Low	Low

For this Urban Climate Risk Profile, risk levels should be interpreted based on the table below.

Table 9. Interpretation of risk levels

Level	Interpretation
Very High	Very high risks are unacceptable. Risk should be avoided, reduced or transferred. Immediate planning and implementation of risk reduction measures is required. Allocate resources and coordinate interventions to prevent or minimize impact.
High	High risks should be actively addressed. Develop and implement mitigation actions promptly. Monitor environmental indicators and ensure readiness of emergency or adaptation measures.
Medium	Medium risks should be managed. Plan and implement mitigation activities to reduce them to acceptable levels. Regularly review climate data and risk levels.
Low	Low risks are acceptable under current conditions. Minimal control or monitoring is needed, provided they remain stable and do not escalate.
Very Low	Very low risks are negligible in terms of likelihood and consequences. No immediate action is required beyond routine monitoring and periodic review.

4.1 Current and Future Climate Risks on Urban Elements

Table 10. Summary of Flooding risks for Karuri Municipality

Category	**Impact Level**	**Current Risk**	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Hazard Level		High	High	Very High	High	Very High
Infrastructure & Services						
Stormwater Drainage	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**

Water & Wastewater Mgmt	Major	**High**	**High**	**Very High**	**High**	**Very High**
Solid Waste Management	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Transport and Mobility	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Energy	Moderate	**Medium**	**High**	**High**	**High**	**Very High**
Economic Infrastructure	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Social Infrastructure	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Emergency Services	Major	**High**	**High**	**Very High**	**High**	**Very High**
Populations						
Urban Residents	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Informal Settlement Residents	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Vulnerable & Marginalized Groups	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Natural Assets						
Urban Green Infrastructure	Moderate	**Medium**	**High**	**High**	**High**	**Very High**
Urban Blue Infrastructure	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Peri-urban & Agricultural Systems	Major	**High**	**High**	**Very High**	**High**	**Very High**

Table 9. Summary of Drought risks for Karuri Municipality

Category	**Impact Level**	**Current Risk**	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Hazard Level		Medium	High	Very High	High	Very High
Infrastructure & Services						
Water & Wastewater Mgmt	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Solid Waste Management	Minor	**Low**	**Medium**	**Medium**	**Medium**	**High**
Energy	Insignificant	**Very Low**	**Low**	**Low**	**Low**	**Medium**
Economic Infrastructure	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Social Infrastructure	Major	**Medium**	**High**	**Very High**	**High**	**Very High**
Emergency Services	Major	**Medium**	**High**	**Very High**	**High**	**Very High**
Populations						
Urban Residents	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Informal Settlement Residents	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Vulnerable & Marginalized Groups	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**
Natural Assets						
Urban Green Infrastructure	Major	**Medium**	**High**	**Very High**	**High**	**Very High**
Urban Blue Infrastructure	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**

Peri-urban & Agricultural Systems	Catastrophic	**Very High**	**Very High**	**Very High**	**Very High**	**Very High**

Table 10. Summary of Extreme Cold risks for Karuri Municipality

Category	**Impact Level**	**Current Risk**	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Hazard Level		Medium	Medium	Low	Medium	Low
Infrastructure & Services						
Transport and Mobility	Major	**High**	**High**	**Medium**	**High**	**Medium**
Energy	Minor	**Low**	**Low**	**Low**	**Low**	**Low**
Social Infrastructure	Major	**High**	**High**	**Medium**	**High**	**Medium**
Emergency Services	Minor	**Low**	**Low**	**Low**	**Low**	**Low**
Populations						
Urban Residents	Major	**High**	**High**	**Medium**	**High**	**Medium**
Informal Settlement Residents	Catastrophic	**Very High**	**Very High**	**High**	**Very High**	**High**
Vulnerable & Marginalized Groups	Catastrophic	**Very High**	**Very High**	**High**	**Very High**	**High**
Natural Assets						
Urban Green Infrastructure	Minor	**Low**	**Low**	**Very Low**	**Low**	**Very Low**
Peri-urban & Agricultural Systems	Major	**High**	**High**	**Medium**	**High**	**Medium**

Table 4.5. Summary of Landslide Risks for karuri Municipality

Category	**Impact**	**Current**	**2050**	**2050**	**2100**	**2100**

	Level	Risk	SSP2-4.5	SSP5-8.5	SSP2-4.5	SSP5-8.5
Hazard Level		Medium	High	Very High	High	Very High
Infrastructure & Services						
Transport and Mobility	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Water & Wastewater Mgmt	Major	**Medium**	**High**	**Very High**	**High**	**Very High**
Energy	Moderate	**Medium**	**High**	**High**	**High**	**Very High**
Social Infrastructure	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Emergency Services	Major	**Medium**	**High**	**Very High**	**High**	**Very High**
Populations						
Urban Residents	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Informal Settlement Residents	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Vulnerable & Marginalized Groups	Catastrophic	**High**	**Very High**	**Very High**	**Very High**	**Very High**
Natural Assets						
Urban Green Infrastructure	Moderate	**Low**	**Medium**	**High**	**Medium**	**High**
Peri-urban & Agricultural Systems	Major	**Medium**	**High**	**Very High**	**High**	**Very High**

Table 4.6. Summary of Wind Risks for karuri Municipality

Category	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5

Infrastructure & Services					
Energy	High	Very High	Very High	Very High	Very High
Transport and Mobility	High	Very High	Very High	Very High	Very High
Social Infrastructure	High	Very High	Very High	Very High	Very High
Economic Infrastructure	High	Very High	Very High	Very High	Very High
Emergency Services	Medium	High	Very High	High	Very High
Populations					
Urban Residents	High	Very High	Very High	Very High	Very High
Informal Settlement Residents	Very High	Very High	Very High	Very High	Very High
Vulnerable & Marginalized Groups	Very High	Very High	Very High	Very High	Very High
Natural Assets					
Urban Green Infrastructure	Medium	High	Very High	High	Very High
Peri-urban & Agricultural Systems	High	Very High	Very High	Very High	Very High

4.2 Geoghraphical Climate Risk Hotspots

Climate risks are not evenly distributed across Karuri Municipality. The following wards face the highest multi-hazard risks:

Cianda Ward – Moderate flood risk occurs in low-lying areas such as Banana town and Gacharage, combined with moderate drought risk. Settlements and smallholder farms are exposed, with waterlogging affecting access roads and limited drainage infrastructure. Key assets such as schools, markets, and small businesses are vulnerable during heavy rainfall.

Ndenderu Ward – Experiences very high drought risk, particularly in areas such as Ndenderu town, and parts of Karura-Ndenderu corridor, with some moderate flood-prone valleys during intense rainfall. Water insecurity affects households, small-scale farming, and horticulture. Crop failures and reduced agricultural productivity are common during prolonged dry periods.

Muchatha Ward – Faces high flood risk in areas such as Muchatha town, and especially along natural drainage paths and built-up areas with poor stormwater management. Homes, streets, and businesses are often inundated during heavy rains. The ward also experiences moderate drought risk, affecting water supply and small-scale urban agriculture.

Kihara Ward – Experiences high extreme cold and frost risk, particularly in elevated areas such as Kihara, Kiambaa, and surrounding tea-growing zones. Cold conditions affect agricultural productivity, especially tea farming, and pose health risks to vulnerable populations including children, the elderly, and residents living in poorly insulated housing.

Karuri Ward – Faces moderate flood and cold risk, particularly in areas around Karuri town and Nderu riverine sections where poor drainage and seasonal water accumulation occur. Some locations near wetlands and drainage channels experience temporary flooding during heavy rainfall. Periodic water shortages during dry spells also affect households, institutions, and small businesses.

5. What's Next?

5.1 Key Findings.

Flooding is the most pervasive and severe hazard in Karuri Municipality, with very high risks already affecting stormwater drainage systems, transport infrastructure, solid waste management, economic activities, and social infrastructure such as schools and health facilities. Flood events also affect multiple population groups, particularly in low-lying and poorly drained areas. Under future climate scenarios, these risks are projected to increase from very high to catastrophic if mitigation and adaptation measures are not implemented.

Drought poses very high risks to water supply, smallholder agriculture, and climate-sensitive livelihoods across the municipality, particularly in Ndenderu and Cianda wards where households depend on rain-fed farming and limited water sources. Prolonged dry spells lead to water shortages, reduced agricultural productivity, and income losses. These risks are projected to increase significantly by 2050 under the RCP8.5 climate scenario.

Extreme cold and frost conditions currently present high risks, especially in high-altitude areas such as Kihara Ward, affecting tea farming and vulnerable populations living in poorly insulated housing. Cold conditions can reduce agricultural yields and expose residents to health risks. Climate projections indicate that cold-related risks may slightly decline under high-emission scenarios, although vulnerable groups will continue to face exposure.

Most at-risk groups:

- Residents of informal settlements
- Elderly persons and children
- Female tea pickers (dependent on daily wages)
- Boda boda operators
- Smallholder farmers .

Trends intensifying future risks:

- Rapid urbanisation reducing pervious surfaces and increasing runoff.
- Continued encroachment on riparian reserves and wetlands.
- Increasing water demand from population growth.
- Limited municipal budget for maintenance and new infrastructure.

Table 11. Summary of climate risks affecting urban elements for Karuri Municipality

Category	Current	Mid-term (2050)	Long-term (2100)
Infrastructure & Services			
Stormwater Drainage	Flooding (Very High)	Flooding (Very High)	Flooding (Very High)
Water & Wastewater Mgmt	Drought (High), Flooding (High)	Drought (Very High), Flooding (Very High)	Drought (Very High), Flooding (Very High)
Solid Waste Management	Flooding (Very High)	Flooding (Very High)	Flooding (Very High)
Transport and Mobility	Flooding (Very High), Cold (High)	Flooding (Very High), Cold (Medium)	Flooding (Very High), Cold (Medium)
Economic Infrastructure	Flooding (Very High), Drought (High)	Flooding (Very High), Drought (Very High)	Flooding (Very High), Drought (Very High)
Social Infrastructure	Flooding (Very High), Cold (High)	Flooding (Very High), Cold (Medium)	Flooding (Very High), Cold (Medium)
Emergency Services	Flooding (High), Drought (Medium)	Flooding (Very High), Drought (High)	Flooding (Very High), Drought (High)
Populations			
Urban Residents	Flooding (Very High), Drought (High), Cold (High)	Flooding (Very High), Drought (Very High), Cold (Medium)	Flooding (Very High), Drought (Very High), Cold (Medium)
Informal Settlement Residents	All three hazards (Very High)	All three hazards (Very High)	All three hazards (Very High)
Vulnerable & Marginalized Groups	All three hazards (Very High)	All three hazards (Very High)	All three hazards (Very High)
Natural Assets			
Urban Blue	Flooding (Very High),	Flooding (Very High),	Flooding (Very High),

Infrastructure	Drought (High)	Drought (Very High)	Drought (Very High)
Peri-urban & Agricultural Systems	Drought (Very High), Flooding (High), Cold (High)	Drought (Very High), Flooding (Very High), Cold (Medium)	Drought (Very High), Flooding (Very High), Cold (Medium)

5.2 Climate Adaptation and Resilience Solutions

The following solutions are drawn from community consultations and the Kiambu County PCRA adaptation strategies. They are prioritised as immediate (0-2 years), mid-term (3-7 years), and long-term (8-15 years).

Table 12. Climate adaptation and resilience solutions recommended for Karuri Municipality

Category	Immediate (0-2 years)	Mid-term (3-7 years)	Long-term (8-15 years)
Infrastructure & Services			
Stormwater Drainage	Desilt and unblock existing roadside drains in Banana, Ndenderu and Ruaka.- Install trash traps at drainage hotspots.- Map the municipal drainage network in GIS.	- Construct lined drainage channels in flood-prone areas (Banana town, Ndenderu trading centre).- Upgrade culverts and drainage crossings on major roads.	- Implement Sustainable Urban Drainage Systems (SUDS) in new developments.- Restore and protect riparian zones along rivers and streams.
Water & Wastewater Management	Promote household rainwater harvesting tanks.- Repair leaks in municipal water distribution networks.- Solarise selected municipal boreholes.	- Expand piped water supply networks to underserved estates.- Construct additional boreholes and community storage tanks.	- Develop climate-resilient municipal water supply systems with large storage reservoirs.- Introduce wastewater recycling and reuse for irrigation.
Solid Waste Management	Provide waste bins in commercial areas and flood-prone zones.- Conduct regular community clean-ups of drainage channels.- Support waste sorting and recycling initiatives.	- Establish a municipal material recovery facility (MRF).- Introduce segregated waste collection systems.	- Implement circular economy strategies and reduce waste sent to landfills.- Develop modern waste treatment facilities.
Transport & Mobility	Repair drainage along major roads prone to flooding.- Grade and maintain murram feeder roads.- Install warning signage at flood-prone road sections.	- Upgrade key murram roads to all-weather standards.- Construct additional culverts and improve road drainage infrastructure.	- Integrate climate resilience into all road design standards.- Develop pedestrian walkways and non-motorised transport networks.
Energy	Trim trees near power lines to reduce storm damage.- Expand solar street lighting in residential areas.	- Promote solar water heating and rooftop solar in households and institutions.	- Develop decentralised renewable energy systems and micro-grids.
Economic Infrastructure	Improve drainage in markets and trading centres.- Train small traders and farmers on climate risk management.	- Construct cold storage facilities to reduce food losses.- Promote climate-smart agribusiness and food supply systems.	- Establish climate-resilient commercial centres and markets.
Social	Install rainwater harvesting tanks in schools and	- Retrofit selected schools and clinics to improve	- Develop model climate-resilient schools and

Category	Immediate (0-2 years)	Mid-term (3-7 years)	Long-term (8-15 years)
Infrastructure	health facilities.- Improve sanitation facilities in public institutions.	resilience to floods and storms.	healthcare facilities.
Emergency Services	Develop ward-level disaster preparedness plans.- Train community emergency response teams (CERTs).	- Install local weather monitoring and early warning systems.- Equip emergency services with disaster response equipment.	- Establish a municipal disaster management and operations centre.
Populations			
Urban Residents	Conduct public awareness campaigns on flood safety and water conservation.- Promote rainwater harvesting at household level.	- Provide subsidies or incentives for household water storage systems.- Expand access to affordable health insurance.	- Integrate climate resilience standards into housing regulations.
Informal Settlement Residents	Improve sanitation and drainage in informal settlements.- Provide temporary safe water access points.	- Implement participatory slum upgrading programs.- Improve access to basic infrastructure services.	- Implement in-situ upgrading with climate-resilient housing and services.
Vulnerable & Marginalised Groups	Register vulnerable groups for social protection programmes.- Conduct targeted climate risk awareness programmes.	- Develop livelihood diversification programmes for vulnerable households.- Provide grants for youth entrepreneurship in climate-resilient sectors.	- Implement inclusive climate action plans with dedicated funding for vulnerable groups.
Natural Assets			
Urban Green Infrastructure	\Plant indigenous trees along streets and in public spaces.- Protect existing green spaces.	- Develop urban green corridors along rivers and roads.- Establish community tree nurseries.	- Increase municipal tree cover significantly through long-term urban forestry programmes.
Urban Blue Infrastructure	Demarcate and protect riparian zones.- Remove encroachments along rivers.	- Restore degraded riverbanks and wetlands.- Promote nature-based flood control measures.	- Fully rehabilitate urban wetlands and integrate them into green infrastructure networks.
Peri-urban & Agricultural Systems	Train farmers on drought-resilient farming practices.- Promote water-efficient irrigation methods.	- Expand drip irrigation and agroforestry systems.- Support climate-smart agriculture programmes.	- Develop peri-urban areas as climate-smart agriculture hubs supporting urban food security.

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Annex N1. Data Sources

Page	Data	Data Source
8	Population figures, ward-wise	KNBS 2019, Kiambu CIDP 2023-2027
13	Hazard screening	PCRA karuri Sub-County consultations, 2023
14	Climate indicators, thresholds	KMD, CHIRPS, CORDEX-Africa, ERA5-Land
14	Current hazard levels	Kiambu County PCRA (Chapter 3)
18	Future hazard projections	Kiambu County PCRA (Chapter 4) – downscaled CMIP5
21	Urban elements inventory – infrastructure	Karuri Municipal Board asset register (2024)
17	Informal settlement data	Ward administrators, PCRA community mapping
24-35	Exposure, vulnerability, impacts	PCRA community workshops, 2023; expert judgment
36-41	Risk levels	Derived using IPCC AR5 risk framework
41	Climate risk hotspots	PCRA hazard maps, municipal physical planning
46	Adaptation solutions	PCRA adaptation strategies (Table 4,15,16)