



COUNTY GOVERNMENT OF LAIKIPIA
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NANYUKI

NANYUKI MUNICIPALITY CLIMATE RISK PROFILE

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Foreword

This Climate Risk Profile for Nanyuki Municipality provides a structured and evidence-based assessment of climate-related hazards, exposure, vulnerability, and risk. The report is intended to guide climate-responsive planning, infrastructure investment, and policy development within the Municipality and Laikipia County. It supports integration of climate resilience into spatial planning, service delivery, and sustainable urban development. The purpose is:

- Identification of key climate hazards
- Assessment of exposure of municipal assets and services
- Evaluation of vulnerability factors
- Risk rating using likelihood and impact
- Determine overall climate risk levels
- Recommend appropriate climate risk management measures

Climate risk is determined as:

Risk = Hazard, Exposure and Vulnerability

This ensures that municipal plans, projects, and investments are resilient to current and future climate risks.

Executive Summary

Nanyuki Municipality provides a rapid, evidence-based assessment of current and future climate risks to urban systems, populations, and natural assets. The profile is prepared in line with the Global Centre of Adaptation (GCA) Urban Climate Risk Profile Guidelines, 2025, and is informed primarily by the Climate Risk Assessment, the climate information from Kenya Meteorological Department under State Department of Environment and Climate Change, the Laikipia County Spatial Plan, and stakeholder consultations.

The municipality is increasingly exposed to climate variability and long-term climate change impacts including drought and water scarcity, rainfall variability, flash floods, temperature variability, environmental degradation water Stress, Heat Stress and Gully Erosion, Storms (rainfall with strong winds).



Water stress presents the current and future risks, particularly to stormwater drainage, water supply systems, transport infrastructure, informal settlements, and vulnerable populations. Climate projections indicate increasing rainfall intensity and rising temperatures by 2030 and 2050, especially under high emissions scenarios, which will exacerbate existing vulnerabilities. Without targeted adaptation measures, risks to infrastructure, service delivery, livelihoods, and public health will escalate.

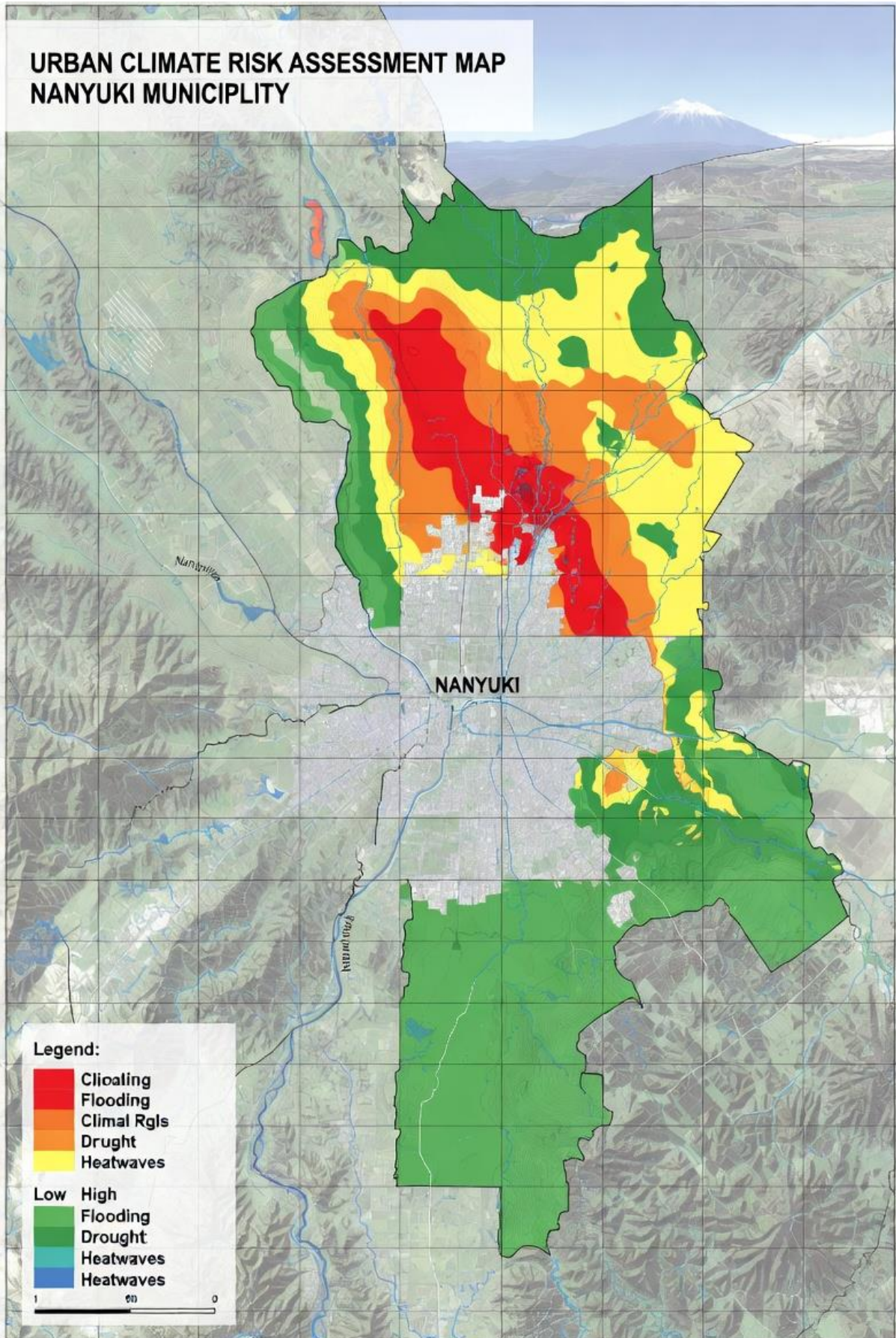
Key recommended actions include immediate drainage maintenance and solid waste control, medium-term investments in water security and green infrastructure, and long-term integrated land-use planning and catchment management to build climate resilience across the municipality.

Key hazards include These hazards intersect with rapid urbanization, infrastructure gaps, and ecosystem pressures, elevating climate risk.

The overall risk profile indicates that drought and environmental degradation pose high risks, while flash floods and heat stress represent moderate but growing risks. Strategic priorities include strengthening water security, enhancing green infrastructure, improving drainage systems, enforcing land-use planning, and institutionalizing climate risk screening.



URBAN CLIMATE RISK ASSESSMENT MAP NANYUKI MUNICIPALITY



Flooding risks

	Period	Current	2030	2050	2070	2100
	Hazard Level	Medium	High	High	Very High	Very High
Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100
Infrastructure and Services						
Stormwater Drainage	Soil erosion, drainage blockage, localized flash flooding	Medium	High	High	Very High	Very High
Water & Wastewater Management	Flooded sewer lines, contamination of water sources	Medium	High	High	Very High	Very High
Solid Waste Management	Waste washed into drains and rivers, worsening floods	Medium	High	High	Very High	Very High
Transport and Mobility	Road flooding, riparian lands and bridge overtopping, traffic disruption	Medium	High	High	Very High	Very High
Energy	Power outages, substation flooding	Medium	High	High	Very High	Very High
Economic Infrastructure	Disruption in cbd, markets, SMEs, institutions, residential industrial areas	Medium	High	High	Very High	Very High

Social Infrastructure	Flooding of schools, health facilities	Medium	High	High	Very High	Very High
Emergency Services	Limited access and response time during floods	Medium	High	High	Very High	Very High
Populations						
Urban Residents, flood prone areas.	Property damage, health risks, Region displacements	Medium	High	High	Very High	Very High
Informal Settlement Residents	Loss of shelters, high exposure along riverbanks	Medium	High	High	Very High	Very High
Vulnerable and Marginalized Groups	Increased disease risk, livelihood loss	Medium	High	High	Very High	Very High
Natural Assets						
Urban Green Infrastructure	Erosion, degradation, loss of flood buffering	Medium	High	High	Very High	High
Urban Blue Infrastructure	Riverbank erosion, wetland degradation	Medium	High	High	Very High	Very High
Peri-urban and Agricultural Systems	Crop damage, soil erosion, livelihood loss	Medium	High	High	Very High	Very High

Drought and water stress risks

	Period	Current	2030	2050	2070	2100
	Hazard Level	Medium	High	Very High	Very High	Very High
Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100
Infrastructure & Services						
Stormwater Drainage	Limited-drainage system flow, sediment buildup	High	High	High	High	High
Water & Wastewater Management	Water-shortages, reduced treatment efficiency	High	High	Very High	Very High	Very High
Solid Waste Management	Limited cleaning capacity, public health risks	Medium	High	High	High	High
Transport and Mobility	Dust, reduced road durability	Medium	Very High	Very High	Very High	Very High
Energy	Reduced hydropower reliability, cooling essential needs	Medium	Medium	Medium	Medium	Medium
Economic Infrastructure	Reduced productivity, higher operating costs	High	High	High	Very High	Very High
Social Infrastructure	Water-scarcity	High	High	High	Very High	Very High

Emergency Services	Limited water for firefighting	High	High	High	High	High
Populations						
Urban Residents	Intermittent supply, increased costs	Very High	Very High	Very High	Very High	Very High
Informal Settlement Residents	Acute shortages, reliance on unsafe sources	Very High	Very High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	Health risks, reduced coping capacity	Very High	Very High	Very High	Very High	Very High
Natural Assets						
Urban Green Infrastructure	Vegetation stress, loss of cooling	Very High	Very High	Very High	Very High	Very High
Urban Blue Infrastructure	Reduced flows, degraded water quality	Very High	Very High	Very High	Very High	Very High
Peri-urban and Agricultural Systems	Crop losses, livestock stress	Very High	Very High	Very High	Very High	Very High

Heat stress risks

	Period	Current	2030	2050	2070	2100
	Hazard Level	High	High	Very High	Very High	Very High
Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100

Infrastructure & Services						
Stormwater Drainage	Thermal stress on structures, low flows	Medium	High	High	Very High	Very High
Water & Wastewater Management	Higher demand vs limited services supply	Medium	High	High	High	High
Solid Waste Management	Hazardous Oduor, environment workers exposure, health risks	Medium	High	High	High	High
Transport and Mobility	surface degradation, heat exposure	Medium	High	High	High	High
Energy	Increased cooling demand, outages	Medium	High	High	High	High
Economic Infrastructure	Productivity loss, heat related downtime	Medium	High	High	High	High
Social Infrastructure	Overheated schools and health facilities	Medium	High	High	High	High
Emergency Services	Increased heat-related emergencies	Medium	High	High	High	High
Populations						
Urban Residents	Discomfort, health stress	Medium	High	High	High	Very High
Informal Settlement Residents	Severe indoor heat, dehydration	Medium	High	High	High	Very High
Vulnerable and Marginalized Groups	Heat illness, mortality risk	Medium	High	High	High	Very High
Natural Assets						

Urban Green Infrastructure	Heat stress, reduced cooling capacity	Medium	Medium	Medium	High	High
Urban Blue Infrastructure	High evaporation rate, lower cooling effect	Medium	Medium	Medium	High	High
Peri-urban and Agricultural Systems	Crop stress, reduced yields	Medium	High	High	Very High	Very High

Extreme rainfall variability risks

	Time Horizon & Climate Scenario	Current	2030	2050	2070	2100
		Hazard Level	Low	High	High	High
Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100
Infrastructure & Services						
Stormwater Drainage	Overtopping during storms; inefficiency in dry periods	Medium	High	High	High	High
Water & Wastewater Management	Treatment overload and low-flow stress	Medium	High	High	High	High
Solid Waste Management	Waste mobilization during storms	Medium	High	High	High	High
Transport and Mobility	Flooded roads, soil erosion, delays	Medium	High	High	High	High
Energy	Disruption from storms and erosion	Medium	High	High	High	High

Economic Infrastructure	Business interruptions, damage	Medium	High	High	High	High
Social Infrastructure	School and health facility disruption	Medium	High	High	High	High
Emergency Services	Increased demand, reduced access	Medium	High	High	High	High
Populations						
Urban Residents	Property damage, safety risks	Medium	High	High	High	High
Informal Settlement Residents	Flooding, landslide exposure	Medium	High	High	High	High
Vulnerable and Marginalized Groups	Health risks, livelihood loss	Medium	High	High	High	High
Natural Assets						
Urban Green Infrastructure	Erosion and vegetation stress	Medium	High	High	High	High
Urban Blue Infrastructure	Flash flooding, sedimentation	Medium	High	High	High	High
Peri-urban and Agricultural Systems	Crop losses, soil erosion	Medium	High	High	High	High

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List of Acronyms

Acronym	Full Term
ADB	African Development Bank

ASALs	Arid and Semi-Arid Lands
BPO	Business Process Outsourcing
CBD	Central Business District
CCAP	County Climate Action Plan
CCCF	County Climate Change Fund
CCD	Climate Change Directorate
CIDP	County Integrated Development Plan
CSO	Civil Society Organization
DEM	Digital Elevation Model
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EMCA	Environmental Management and Coordination Act
EPRA	Energy and Petroleum Regulatory Authority

FLLoCA	Financing Locally-Led Climate Action
GCA	Global Center on Adaptation
GHG	Greenhouse Gas
GIS	Geographic Information System
GoK	Government of Kenya
ICT	Information and Communicatio n Technology
IDEP	Integrated Development and Economic Plan
IPCC	Intergovernme ntal Panel on Climate Change
KMD	Kenya Meteorologica l Department
KUSP	Kenya Urban Support Program
KUSP-II	Kenya Urban Support Program – Phase II
MIDP	Municipal Integrated Development Plan
NCCAP	National Climate Change Action Plan

NAP	National Adaptation Plan
NDMA	National Drought Management Authority
NEMA	National Environment Management Authority
NGO	Non- Governmental Organization

NA	Nanyuki Water and Sanitation Company
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WASCO	
PCRA	Participatory Climate Risk Assessment
PWD	Persons with Disabilities
RCRA	Rapid Climate Risk Assessment
SSP	Shared Socioeconomic Pathway
UCRP	Urban Climate Risk Profile
UHI	Urban Heat Island
UNFCCC	United Nations Framework Convention on Climate Change
WRA	Water Resources Authority

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1. Context

Objective

This Urban Climate Risk Profile aims to identify and assess key climate hazards affecting Nanyuki Municipality which is located in Laikipia County at the foothills of Mount Kenya, within a semi-arid to sub-humid climatic zone and experiences increasing climate variability. It serves as a commercial, tourism, agricultural, and transport hub in Kenya’s central highlands. The municipality experiences a bimodal rainfall pattern with long rains (March–May) and short rains (October–December).

Rapid urban expansion, increasing demand for services, pressure on water resources, expanding informal settlements, aging infrastructure, all of which heighten sensitivity to climate-related hazards and environmental pressures have heightened sensitivity to climate shocks. The Municipality relies heavily on surface and groundwater sources influenced by the Ewaso Nyiro Basin.

The aim is to analyze exposure and vulnerability of urban systems, populations, and natural assets, evaluate current and future climate risks under different climate scenarios and provide a basis for climate adaptation and resilience planning at the municipal and county levels.

Urban Context

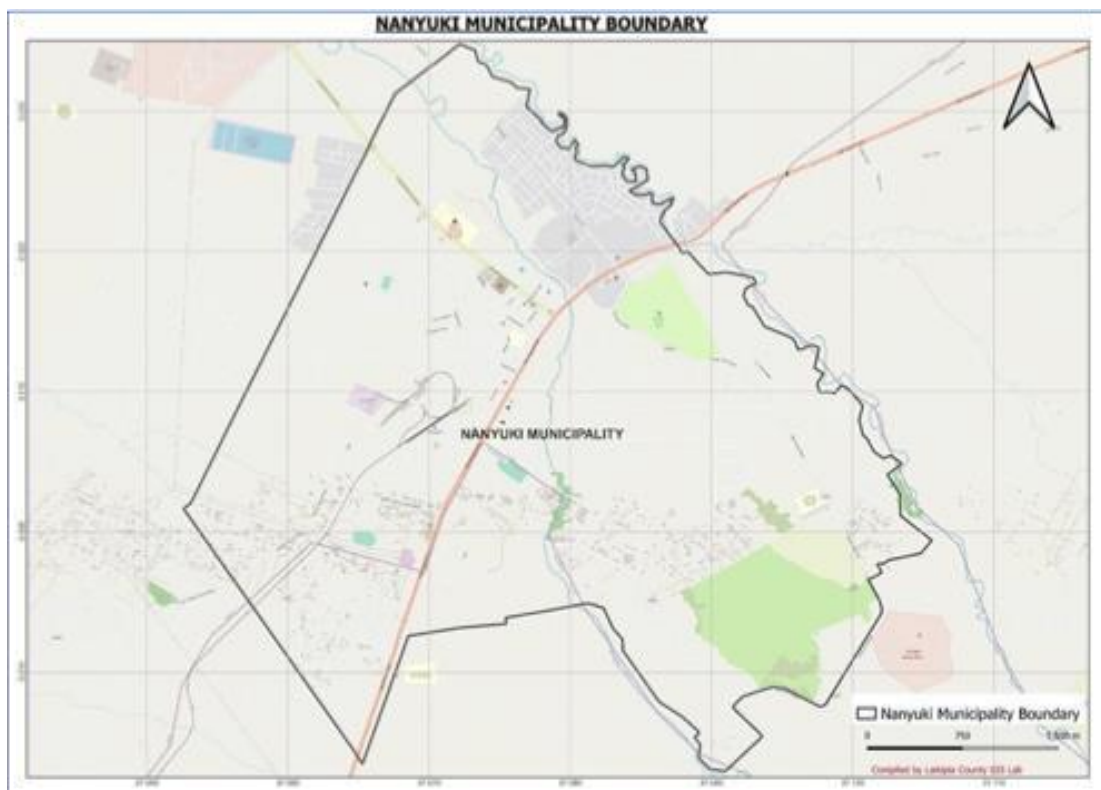
Geographic area

Historical Background of Nanyuki Municipality

Nanyuki town derives its name from the Maasai community. From history, the Maasai had a fierce confrontation with the Purko community along the banks of one of the local rivers. Many Morans were slaughtered in the battle and the river came to be known as “Engare Nanyuikie” meaning, the river of blood and therefore, the name

Nanyuki. The town is located in central Kenya, lying northwest of Mount Kenya along the A2. It was founded in 1907 by British settlers, some of whose descendants still live in and around the town. The settlers, mainly ex-British soldiers had acquired land in the outlying area and embarked on farming activities; mainly wheat growing and cattle and sheep rearing.

These farming activities triggered mushrooming commercial establishments within the center, leading to steady growth. By 1930 the consistent growth and the economic potentials of both the center, and its outlying neighborhood had justified the construction of a railway line connecting the town to Nairobi. This was accomplished in 1954 under the then Aberdare Area council. In 1974 the center attained the status of a town council. Through the same steady growth, the town was elevated to its current status of a municipal council in 1982. Nanyuki has grown to be a military town with the main airbase of the Kenya Air Force, British Army (BATUK) and Kenya Army. Overtime, the expansion of the town has been rapid .



Nanyuki Municipality Boundary

Source: Department of Lands

The boundaries of the Municipality of Nanyuki are as now existing (the entire former Municipal Council of Nanyuki area of jurisdiction within Laikipia county as per the approved Development No 125 of 1992 Ref No

R54/90/3 for Nanyuki Municipality) covering an area of approximately 17 Km² or as may subsequently be altered shall be the boundaries of the Municipality of Nanyuki.



ADMINISTRATIVE STRUCTURE AND FUNCTIONS

The National Government is represented in Nanyuki Municipality through ministries and state corporations. The municipality hosts a number of both national and county government offices. In addition, several parastatals and service departments have offices in the town.

The County Government has several arms all of which have offices hosted at Nanyuki. The executive arm comprises of various County Executive Committee Members (CECM) who head different departments in the county. The chief officers manage the day- to-day administrative affairs of each department. The County Government has Eight (8) departments.

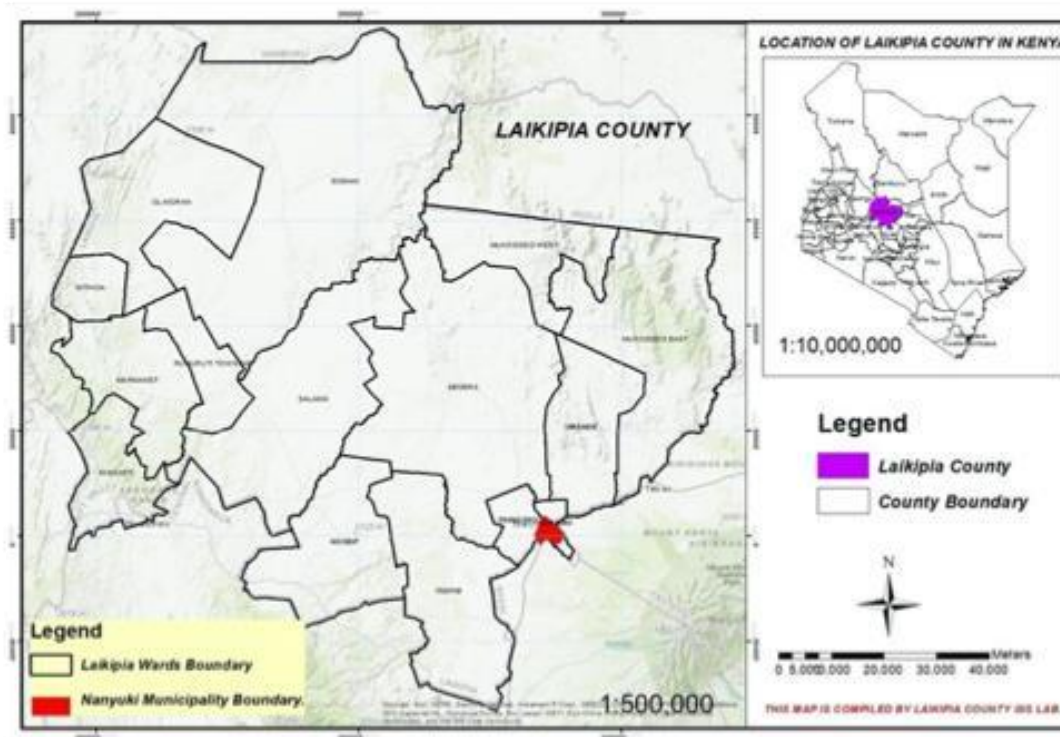
These departments are:

1. County Administration, Public Service and Office of The Governor
2. Finance Planning and Accounting.
3. Health and Sanitation.
4. Education and Youth Development.
5. Agriculture, Livestock and Fisheries.
6. Infrastructure, Land, Housing, Energy and Urban Development
7. Trade, tourism and enterprise development.
8. Water, Environment and Natural resources.

Political units

Nanyuki Municipality is within the Laikipia East Constituency that is a political unit represented by elected persons at the national level. At the County administrative level, the municipality is located in Laikipia East Sub- County and is shared between two wards, Nanyuki and Thingithu Wards.

Sub County Wards



Map 2: Location Context of Nanyuki Municipality

Source: Department of Lands

Population projection

According to the 2019 Population and Housing Census, the proposed Nanyuki Municipality had a population of 72,813. The proposed municipality is projected to have an estimated population of 76,745 in 2021 and 87,441 in 2026 and 99,652 in 2031 using the annual average population growth rate of the entire Laikipia county estimated at 2.64% by the 2019 KPHC report.

Physiographic and Natural Conditions

(Physical and Topographic Features)

Relief and Topography

Mt. Kenya has great significance on the climatic conditions and development of the Municipality. The Municipality is situated along the equator, at the foot of Mt. Kenya on the lee ward side which impacts negatively on the amount and distribution of rainfall. It slopes gently from highlands in the south to the lowlands in the north. The Municipality is at an elevation of about 1947.4 meters above sea level. This high elevation gives the Municipality its cooler climate in contrast to what would be expected along the equator.

Geological and Soil Characteristics

Geological and soil characteristics greatly determine the form a town takes. The major concern being the earth's tectonic forces. Location of urban centers in areas with weak geological structure can be hazardous hence the prudent option will be to avoid development in such areas.

Geological Characteristics

Kenyan lava and agglomerate of the Mt. Kenya volcanic series form the main geological formation for Nanyuki town and its environs. Underlying this is an undifferentiated basement system of rocks consisting of gneisses, granulite's and schists. These rocks have a strong foundation to promote intensive urban development.

Soils

Nanyuki Municipality has predominantly black cotton soils that are poorly drained therefore can only support heavy urban development if the foundation is excavated deeper.

Agro-Ecological Zones

Over 60 per cent of Nanyuki Municipality and its hinterland are covered by Agro-ecological Zone 3 to 5 which constitute medium to low potential areas for agricultural production. These zones cover mainly the western, central and northern areas of the basin. High potential areas cover about 30 per cent of the area and are mainly found near the mountain. Pastoralism, the main means of livelihood in these areas, experiences severe difficulties under these conditions.

Climate

The climate is influenced by two factors namely; its lee wards position in regard to the moisture carrying eastern winds and; its altitude -1947M above sea level.

Rainfall

Nanyuki Municipality is situated in an ASAL area and at the foot of Mt. Kenya on the lee ward side which impacts negatively on the amount and distribution of rainfall. The Municipality receives seasonal relief rainfall with an annual average rainfall ranging from 600-900mm with the annual distribution of the rain varying very much in the area. Rainfall cannot adequately support agriculture hence need to diversify to other economic to support the town's economy

Temperature

The Municipality's average maximum temperature is about 25-27°C while the minimum temperature is about 8 – 13°C. The northern part of the Municipality is hotter compared to the southern part that are cooler due to close proximity to Mt. Kenya

Sunshine and Solar Radiation

Being semi-arid, Nanyuki receives reliable sunshine throughout the year. Nanyuki experiences an annual mean of approximately 10 hours of sunshine per day. The intensity is high resulting in high evapotranspiration rates. The moderate temperatures and high solar hours present an opportunity for enhancing solar power exploitation.

Wind Run

The Municipality has an annual average wind run of 196km/day. The wind run reduces as the altitude decreases. This wind run rate is sufficient to generate wind energy.

Hydrology and Drainage Systems

The Municipality is drained by two main rivers namely Nanyuki and Likii rivers that drain into Ewaso Nyiro downstream. These two rivers form a major structuring element of the town. The rivers have a great influence in the settlement patterns as they are a source of water both for human and livestock consumption and irrigation activities. These rivers are faced with many challenges including encroachment, pollution (from improperly treated sewage and uncollected

garbage), water abstraction by flower farms and failure to observe riparian. This has led to water pollution, water-borne diseases, and environmental degradation among others.

Infrastructure Development

Road, Rail Network, Airports and Airstrips

Roads

Nationally and regionally Nanyuki Municipality is accessed by the international (A2) road that passes through the town from Nairobi to Isiolo. Nanyuki can be accessed at a distance from Isiolo, Meru, Nyeri, Maralal and Nyahururu. It can therefore be fairly accessed from a of towns within its regional context due to its centrality. This centrality gives Nanyuki town prominence and therefore can act as a good economic hub for the south-western region of the country.

Approximately 60% of the roads in the CBD are tarmacked. Most roads in the peri urban are unclassified roads. Most of the roads are of murrum standards hence impassable during rainy seasons. Other sections are roads have been encroached making them narrow.

Air transport

Nanyuki Municipality is served by air transport. The Nanyuki Airstrip is located approximately 8 kilometers from Nanyuki town center and is a government-owned, privately leased airfield, serving private and commercial air operators.

Information Communications and Technology

The municipality is fairly developed as a result of the advent of mobile telephony and internet hubs in the urban centers. The mobile phone coverage stands at more than 90%.

Energy Access

Energy is the driving force for economic growth of towns. Modern towns consume large amounts of fuel, and the energy industry is a crucial part of the infrastructure and maintenance of society in almost cities. The main energy sources in the Nanyuki are electricity, petroleum fuel and wood fuel. Most of the energy sources in Nanyuki are nonrenewable sources of energy.

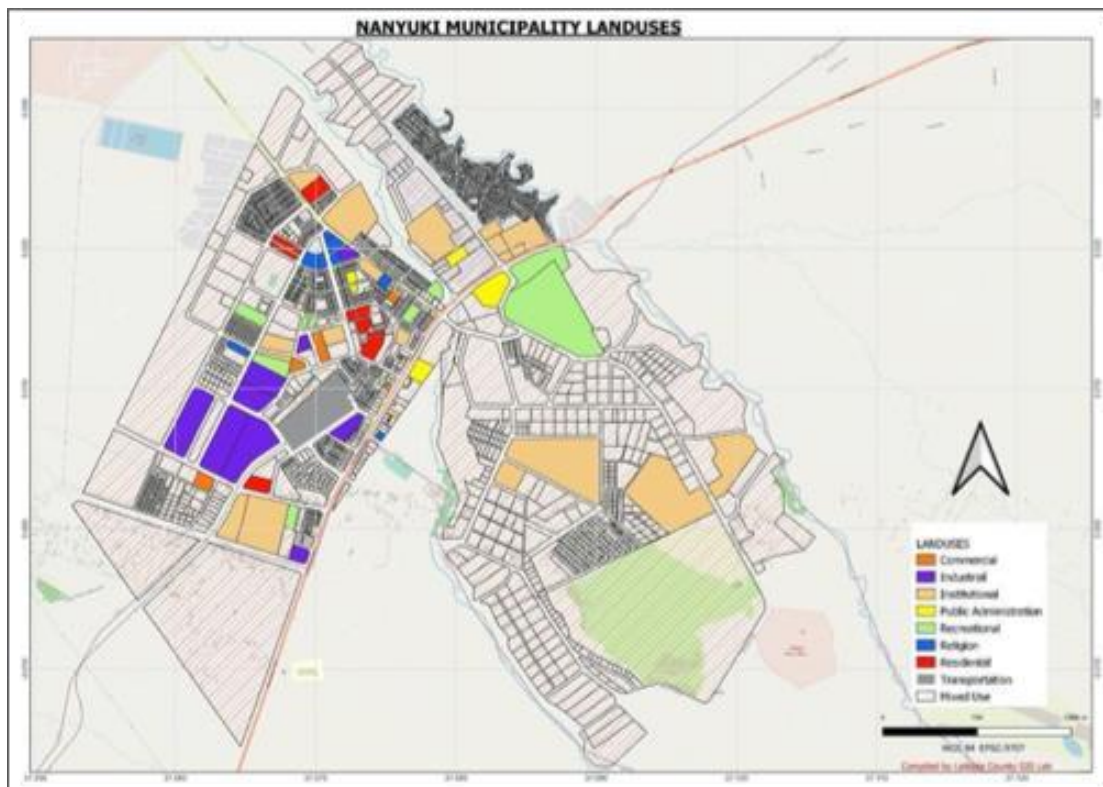
Use of Green energy such solar and wind geothermal that has less negative impact to the environment is minimal.

Electricity used in Nanyuki Municipality is generated from hydropower and is supplied in Nanyuki town by Kenya Power from the national electricity grid. Nanyuki town is well covered by electricity.

Housing

The duality of both rural and urban housing stands out in Nanyuki Municipality. There are numerous typologies of housing in the Municipality.

Land and Land use



Map 3: Nanyuki Municipality Land Uses

Source: Department of Lands

Land ownership categories/classification

Most of the land in the municipality is owned by individuals with big number of the C.B.D having allotment letters and leases.

Settlement Patterns

The settlements in the municipality are clustered as per the Zones.

Type and Size of Land

The type of land in the municipality is either Leases, permanent with letters of Allotment from N.L.C and temporary occupation license (TOL). The small size land holding is approximately 0.045 Ha.

Employment

In the municipality, the dwellers are either in the informal or formal sector.

Irrigation infrastructure and schemes

Irrigation potential

The current land under irrigation has challenges of water rationing and therefore agricultural production potential is not realized. .

Crop, Livestock, Fish Production and Value addition

Main crops produced

The main food crops grown in the county are maize, beans, horticulture and vegetables

Tourism and Wildlife

Classified / Major Hotels

In the municipality there is a wide range of high quality and affordable hotels, lodges, guest houses and Restaurants.

Industry and Trade

Markets

Markets are important for town for many reasons as they offer and create incredible opportunities for social, cultural, and economic wealth at the local level. Apart from contributing significant revenue generation to the county government, markets also enhance the town's local economy. The county operates three markets i.e. The New Market. Nanyuki Old market; and Nanyuki Mtumba market.

Industrial

Historically Nanyuki town was an industrial town. However, most industrial establishments have collapsed. Only a few establishments such camel milk industry, flour mills, KCC among others exist. The industrial zone is located to the west of the town center at railways station.

CLIMATOLOGY

CLIMATE BASELINE

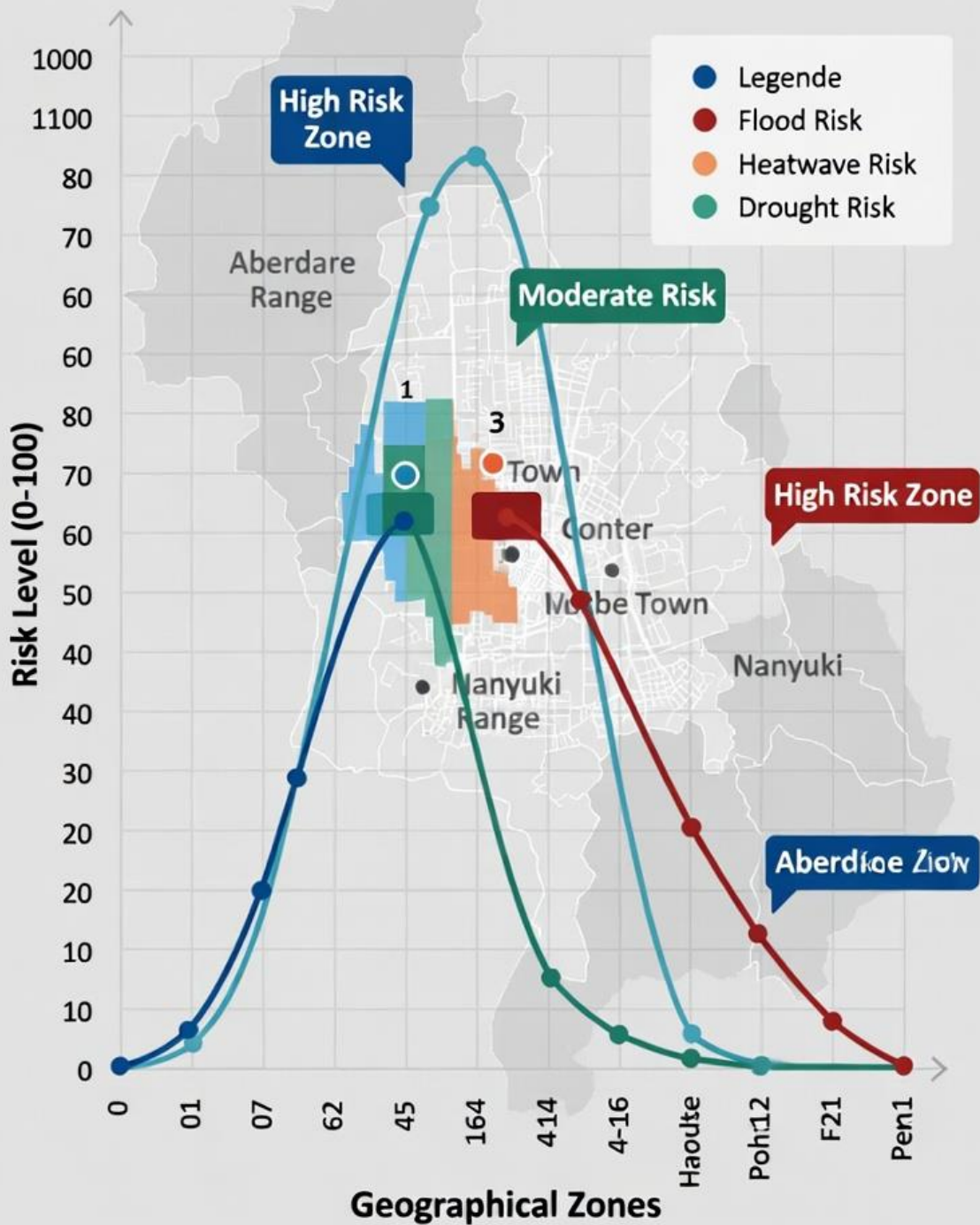
Historic climate data shows a decrease in precipitation and increasing temperatures. The County continues to suffer extreme weather events especially droughts occurring every 2-3 years and occasional floods. Anomalies in the weather have been associated with high malnutrition, due to crop failure and livestock losses and conflicts. In as much as there are deliberate efforts to reduce the impacts of extreme weather events, identification of long-lasting strategies to build resilience to climate change is paramount in ensuring food security, sustainable development and minimization of the resource-based conflicts common in the county.

Laikipia has a diverse natural resource base, which includes forests, wetlands, dry lands, aquatic and marine resources. Laikipia's natural resource base is under increasing strain due to population pressures, coastal erosion, deforestation, poor land management as well as seasonal

variability and climate change. These pressures also threaten the county’s unique biodiversity, as well as local livelihoods and long-term food security for a significant segment of the population.

Climate Variables	2000-2023
Mean Annual Temperature (°C)	8-13
Mean Annual Precipitation (mm)	400-900
Mean Maximum Annual Temperature (°C)	25-27
Mean Minimum Annual Temperature (°C)	9.8

Nanyuki Urban Climate Risk Assessment



Key Stakeholders & Inclusiveness

Purpose of Stakeholder Engagement in the UCRP

Stakeholder engagement in the development of the Urban Climate Risk Profile ensures that there is a common understanding of the challenges and aspirations as it reflects local realities, lived experiences, and indigenous knowledge, provides actionable information on the municipality's priorities for addressing its most pressing risks, and builds ownership for implementation and mainstreaming of climate actions into county and municipal plans (CIDP, MIDP, sector plans). Stakeholder engagement also ensures that the document is scientifically credible, socially inclusive, and politically legitimate.

Legal and Policy Framework Guiding Engagement

Stakeholder participation in the UCRP preparation is guided by:

1. Constitution of Kenya (2010) – Article 10 & Article 174 (public participation and devolution)
2. Climate Change Act (2016) – stakeholder consultation and county climate governance
3. Urban Areas and Cities Act (2011, amended 2019) – participatory urban planning
4. County Governments Act (2012) – citizen engagement frameworks
5. County Public Participation Act (2015)
6. County Climate Change Fund Regulations
7. Municipality Integrated Development and Economic Plan (IDEP)
8. National Climate Change Action Plans (NCCAPs)
9. Participatory Climate Risk Assessment (PCRA)
10. County Climate Action Plan (CCAP)

Policy and Institutional Framework

National Policy and Legal Framework

Kenya has a well-established climate governance framework that provides the legal and policy.

EMCA (1999) & Waste Management Regulations (2006): control of waste transportation, disposal, licensing, record keeping; prevent open burning; maintain site hygiene and leachate control.

Occupational Safety & Health Act (2007): PPE, safe plant operation, incident reporting, training, risk assessments.

Public Health Act (Cap 242): nuisances, sanitation standards, cemeteries and burial hygiene.

County Governments Act (2012) & Urban Areas and Cities Act (2011): service delivery standards, citizen participation, performance reporting.

A compliance checklist aligned to these instruments appears in Section 9.

Climate Change Act, 2016

Establishes the National Climate Change Council and Climate Change Directorate (CCD).

National Climate Change Action Plan (NCCAP)

Operationalizes the Climate Change Act through priority adaptation and mitigation actions.

Kenya National Adaptation Plan (NAP) 2015–2030

Provides long-term adaptation priorities for climate-sensitive sectors such as water, agriculture, infrastructure, and health.

Supports municipal-level climate risk assessments and adaptation planning.

Physical and Land Use Planning Act, 2019

Mandates risk-informed land-use planning and development control.

Disaster Risk Management and Sectoral Policies

National Disaster Risk Management Policy, Water Act, Environmental Management and Coordination Act (EMCA), and Energy policies support preparedness, response, and resilient infrastructure development.

Water catchment protection, and ecosystem-based adaptation.

Sectoral County Departments

Departments of Water, Roads, Health, Environment, Trade, and Social Services are responsible for implementing climate-responsive measures within their mandates.

Municipal Integrated Development Plan (MIDP)

Translates county priorities into urban-specific development actions.

The Urban Climate Risk Profile provides the evidence base to integrate climate risk reduction and adaptation measures into the MIDP.

Municipal By-laws and Development Control

Support enforcement of drainage protection, riparian setbacks, solid waste management, and building standards relevant to climate risk reduction.

Institutional Roles and Responsibilities

Institution	Role in Urban Climate Risk Management
National Climate Change Directorate (CCD)	Policy guidance, coordination, and reporting on climate action
Kenya Meteorological Department (KMD)	Climate data, projections, and early warning information
Laikipia County Government	Planning, budgeting, and implementation of climate responsive development

Nanyuki Municipality	Urban planning, infrastructure management, service delivery, and local adaptation actions
County Disaster Management Unit	Preparedness, response, and recovery from climate-related hazards
Water Resources Authority (WRA)	Protection and regulation of water resources and catchments
NEMA	Environmental regulation and enforcement
Community Institutions & CSOs	Local knowledge, community-based adaptation, and public participation
Development Partners	Technical and financial support for climate resilience initiatives

2. Hazard Assessment

This chapter identifies and analyses climate related hazards that affect Nanyuki Municipality examining the trends by looking at their frequency, intensity and severity, and spatial distribution, and evaluates their historical occurrences and projected climate change influence. This assessment forms the foundation for risk analysis, vulnerability mapping, and adaptation planning.

Drought and Water Scarcity

Prolonged dry spells and erratic rainfall reduce water availability thus affecting domestic supply, agriculture, and economic activities. Reduced surface and groundwater availability has inevitably increased competition for limited water resources.

Rainfall Variability and Flash Floods

Intense unpredictable rainfall events led to overwhelm of stormwater systems which block leading to localized flooding, road damage, erosion, and property loss especially in low -lying areas.

Temperature Variability and Heat Stress

Increasing of temperature from average variability contributes to higher water demand, reduced productivity, heat exposure and public health risks especially in densely built-up regions.

Environmental Degradation

Land degradation, deforestation, riparian reserves encroachment, vegetation cover loss and drainage systems overwhelm due to solid waste hence reduce ecological resilience and amplify climate hazards.

Hazard	Hazard (Y/N)	Impact (Y/N)	Priority (Y/N)	Extreme Hazard (Y/N)
Heat Stress				
Average surface temperature increase	Y	Y	Y	Y
Average ocean temperature increase	N	N	N	N
Extreme heat	N	N	N	N
Marine heatwaves	N	N	N	N
Cold Stress				

Average surface temperature during winter	N	N	N	N
Extreme cold (e.g., cold spells, frost)	N	N	N	N
Snowfall and ice storms	N	N	N	N
Flooding				
Changes in precipitation patterns	Y	Y	Y	Y
Surface level flooding, including flash flooding and urban flooding	Y	Y	Y	Y
River flooding	Y	Y	Y	Y
Sea level rise	N	N	N	N
Coastal flooding, including storm surges	N	N	N	N
Waterlogging	N	N	N	N
Water Stress				
Hazard	Hazard (Y/N)	Impact (Y/N)	Priority (Y/N)	Extreme Hazard (Y/N)
Drought (meteorological, hydrological)	Y	Y	Y	Y
Groundwater salinization	N	N	N	N
Saline intrusion	N	N	N	N
Wildfire				
Wildfires & bushfires	Y	Y	Y	Y
Storms				

Extreme wind	Y	Y	Y	Y
Tropical cyclones	N	N	N	N
Sand and dust storms	N	N	N	N
Hailstorms	N	N	N	N
Mass Movement				
Landslides	Y	Y	Y	Y
Coastal erosion	N	N	N	N
Gully erosion	Y	Y	Y	Y
Marine Conditions				
Ocean acidification	N	N	N	N
Geophysical*				
Subsidence	N	N	N	N
Earthquakes	N	N	N	N
Volcanos	N	N	N	N

Climate Indicators and Hazard Thresholds

Key Hazard	Climate indicator	Data source	Threshold		
			Low	Medium	High
Flooding	Daily rainfall (mm)	KMD,			>50 mm/day

Landslides	Rainfall intensity & slope	County records			Prolonged heavy rainfall
Drought	Consecutive dry days	KMD			>30 days
Heat stress	Max temperature	KMD			>30°C
Rainfall variability	Seasonal rainfall deviation	KMD			±20%

		Hazard Level			
Hazard	Current	2030	2050	2070	2100
Flooding	Medium	High	High	High	Very High
Landslides	Medium	Medium	Medium	Medium	Medium
Drought	Medium	Medium	High	High	Very High
Heat stress	Medium	Medium	Medium	High	High
Rainfall variability	Medium	High	High	High	Very High

Level	Interpretation
High	Hazard events that are likely to occur with high frequency and/or intensity
Medium	Hazard events that are likely to occur with moderate frequency and/or intensity
Low	Hazard events that are likely to occur with low frequency and/or intensity

Exposure & Vulnerability Assessment

This section examines how climate hazards identified in Section 2 interact with Nanyuki Municipality’s urban systems, populations, and natural assets. Building on the hazard assessment and spatial analysis, it evaluates the degree of exposure of key urban elements to current and projected climate hazards, as well as their vulnerability, considering both sensitivity and adaptive capacity. The assessment draws on municipal infrastructure data, ward level socio-economic characteristics, land-use patterns, and insights from the Laikipia County Integrated Development Plan (CIDP 2023–2027) and related sectoral reports. Particular attention is given to informal settlements, critical infrastructure, and environmentally sensitive areas, where climate impacts are already evident and are expected to intensify under future climate scenarios. The findings of this section provide the analytical basis for determining climate impacts and risks in subsequent sections of the Urban Climate Risk Profile.

Key exposed elements include natural ecosystems, riparian zones, residentials, institutions, transport infrastructure, industrial enterprises, water supply systems, drainage, commercial enterprises, agricultural activities, and public facilities.

Vulnerability drivers include infrastructure deficits, rapid settlement expansion, water dependency, ecosystem degradation, limited waste management systems, highly densely populations around flood-prone area, limited adaptive capacity, limited integrations of climate resilience projects and limited awareness of climate risks among low-income households.

Urban Elements

Key exposed urban elements within Municipality include storm water drainage systems, roads and bridges, water supply infrastructure, economic and social infrastructure such as markets and health facilities, blue infrastructure such as riparian ecosystems, informal settlements residents and vulnerable and marginalized groups among others.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Infrastructure & Services				

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Stormwater Drainage	Stormwater drainage conveyance network	Y	Y	Includes open drains, culverts, roadside channels, and natural drainage lines conveying stormwater. Critical for flood risk assessment, especially in low-lying areas and riparian lands.
	Stormwater storage	Y	N	Includes detention ponds, retention basins, and informal floodplains.

Water & Wastewater Management	Pumping stations	Y	Y	Facilities used to pump water or wastewater where gravity flow is insufficient. Important for service continuity during floods and power outages.
	Groundwater abstraction	Y	N	Boreholes and wells used for municipal and private water supply. Locations often available in tabular form but not fully mapped in GIS. Relevant for drought and groundwater depletion risk.
	Water treatment facilities	Y	Y	Critical assets exposed to flooding, landslides, and drought related water scarcity.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Water supply networks	Y	Y	Distribution pipelines supplying treated water to households and institutions. GIS coverage often incomplete or outdated but essential for service disruption analysis.
	Sewer networks	Y	Y	Sewer lines serving the central business district and planned areas. Informal and peri-urban areas largely rely on on-site sanitation.

	Wastewater treatment facilities	Y	Y	Centralized wastewater treatment plants serving urban town. Key for pollution control during extreme rainfall events.
Solid Waste Management	Transfer facilities	N	N	Waste transfer points and collection yards used before transport to disposal sites. Often informal and poorly documented.
	Landfills and dump sites	Y	Y	Includes designated dumpsites serving Nanyuki Municipality. High climate risk due to flooding, leachate runoff, and slope instability.
	Recycling centers	N	N	Small-scale or informal recycling activities exist but are not formally integrated into municipal systems.
	Collection fleet	Y	N	Municipal and contracted waste collection vehicles. Climate risks include access disruption during flooding.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Transport and Mobility	Road networks	Y	Y	Bitumen and gravel roads forming the primary transport network. Highly exposed to flooding, erosion, and waterlogging.
	Bridges	Y	Y	River and drainage crossings, especially near River. Vulnerable to flooding and scour.

	Public transport networks (rail, bus, mini-bus, etc.)	Y	N	Bus and mini-bus (matatu) routes operating on road network. Routes are disrupted during floods.
	Transportation terminals	Y	Y	Bus parks and termini in urban areas. Often affected by waterlogging and congestion during heavy rains.
	Vehicle depots	N	N	Limited formal depots; mostly private facilities not critical for climate risk analysis.
	Non-motorized transport networks	Y	Y	Footpaths and walkways. Often lack drainage and are easily waterlogged.
	Freight and logistics hubs	N	N	No major logistics hubs within the municipality.
Energy	Energy power plants	N	N	No power generation plants within the municipality.
	Poles and power lines	Y	Y	Overhead electricity distribution infrastructure vulnerable to storms and falling trees.
	Transformers and substations	Y	Y	Electricity distribution substations sensitive to flooding and overheating.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Streetlighting	Y	Y	Public lighting infrastructure vulnerable to flooding and electrical faults.
Economic Infrastructure	Markets	Y	Y	Open-air and covered markets central to livelihoods; highly exposed to flooding and waterlogging.

	Businesses and commercial hubs	Y	Y	CBD and commercial corridors vulnerable to flooding, heat stress, and service disruptions.
	Industrial zones/parks and logistics parks	N	N	No major industrial parks within the municipality.
Social Infrastructure	Government buildings and service centers	Y	Y	County and municipal offices providing essential services; exposed to flooding and heat stress.
	Education facilities	Y	Y	Schools and colleges affected by flooding, heat stress, and water shortages.
	Healthcare facilities	Y	Y	Hospitals and clinics sensitive to floods, disease outbreaks, and power disruptions.
	Public spaces	Y	Y	Parks, playgrounds, and open spaces providing cooling and social functions.
	Religious-based buildings	Y	Y	Churches and religious facilities often used as community shelters during emergencies.
	Cultural and heritage assets	Y	N	Historical and cultural sites with limited spatial documentation.
Emergency Services	Fire stations	Y	Y	Fire response facilities sensitive to access disruption during floods.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Police stations	Y	Y	Security facilities providing emergency response and coordination.

	Telecommunications networks	Y	Y	Mobile towers and communication lines sensitive to storms and power failure.
	Early warning systems	Y	N	Community-based and institutional warning mechanisms; largely nonspatial.
	Disaster management centers and shelters	Y	N	Temporary and permanent facilities used during emergencies; limited mapping.
	Evacuation routes	Y	N	Roads and paths used during emergencies; not formally designated or mapped.
Populations				
Urban Residents	Population	Y	Y	Total population residing within municipal boundaries.
	Households	Y	Y	Household distribution across wards and neighborhoods.
Informal Settlement Residents	Population living in informal settlements	Y	Y	Residents in high-density and unplanned areas with high exposure to floods and service gaps.
	Households lacking land tenure	Y	Y	Tenure-insecure households increasing vulnerability to displacement.
	Households / residents lacking access to basic services	Y	Y	Areas lacking piped water, sewerage, or waste services.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
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Vulnerable and Marginalized Groups	Low-income households	Y	Y	Economically vulnerable groups sensitive to climate shocks.
	Women-headed households	Y	Y	Households with increased care burdens and limited resources.
	Children and youth	Y	Y	High sensitivity to heat, flooding, and disease.
	Elderly persons	Y	Y	Vulnerable to heat and cold stress.
	People with disabilities (PWD)	Y	N	Reduced mobility and evacuation capacity.
	Homeless populations	Y	N	Highly exposed to weather extremes.
	Unemployed or precariously employed workers	Y	Y	Livelihoods easily disrupted by climate events.
	Seasonal workers / migrant laborers	Y	N	Temporary populations with limited social protection.
	Nomadic groups in peri urban areas	N	N	Minimal presence
	Urban refugees and migrants	Y	N	Small but vulnerable populations.
Minority ethnic groups in urban areas	Y	N	Socially vulnerable groups within urban areas.	
Natural Assets				
Urban Green Infrastructure	Urban parks and gardens	Y	Y	Provide cooling, recreation, and storm water regulation.
	Green corridors	Y	Y	Linear green spaces along roads and rivers.
	Street landscaping	Y	Y	Trees and planted areas reducing heat and runoff.
	Urban forests and forest reserves	Y	Y	Nearby forest areas contributing to climate regulation.

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Urban Blue Infrastructure	Natural wetlands	Y	Y	Flood buffering and water filtration functions; some encroachment.
	Rivers	Y	Y	Major flood risk zones.
	Riparian zones	Y	Y	River buffer areas sensitive to encroachment.
	Lakes, ponds and reservoirs	Y	Y	Water storage and supply sources.
	Urban agriculture	Y	Y	Small-scale farming in open and peri-urban spaces.
Peri-urban and Agricultural Systems	Peri-urban agriculture	Y	Y	Crop and livestock systems sensitive to drought and floods.
	Agroforestry systems	Y	Y	Trees integrated with farming improving resilience.
	Forests and forest reserves	Y	Y	Catchment protection and climate regulation.
	Protected areas and national parks	Y	Y	Adjacent conservation areas influencing hydrology.
	Savannahs and rangelands	Y	Y	Improvement on vegetation cover.

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

Key exposed elements include natural ecosystems, riparian zones, residentials, institutions, transport infrastructure, industrial enterprises, water supply systems, drainage, commercial enterprises, agricultural activities, and public facilities.

Vulnerability drivers include infrastructure deficits, rapid settlement expansion, water dependency, ecosystem degradation, limited waste management systems, highly densely populated areas around flood-prone areas, limited adaptive capacity, limited integrations of climate resilience projects and limited awareness of climate risks among low-income households.

Flooding: - High exposure of storm water drainage, roads, informal settlements, and riparian zones.

- High vulnerability due to undersized drainage, encroachment, and limited maintenance.

- Impacts range from major to catastrophic in flood-prone wards.

Drought: - Medium exposure of water supply systems and peri-urban agriculture.

- High vulnerability of low-income households and farmers.

- Impacts are moderate to major.

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

Table 10. Interpretation of exposure and vulnerability levels

Level	Exposure Level Interpretation	Vulnerability Level Interpretation
High	Few or no critical urban elements lie within the hazard footprint or area of impact.	The urban element is vulnerable to the climate hazard due to high natural sensitivity – considering physical and non-physical characteristics – and limited adaptive capacity.
Medium	A moderate number or a mix of low- and medium-value urban elements are located within the hazard footprint.	The urban element is somewhat vulnerable to the climate hazard due to moderate sensitivity and adaptive capacity.

Low	A large number and high-value urban elements (e.g., critical infrastructure, dense neighborhoods, major economic assets) are located within the hazard footprint.	The urban element is minimally vulnerable to the climate hazard due to limited sensitivity and/or a high degree of adaptive capacity.
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		Vulnerability Level		
		Low	Medium	High
Exposure Level	High	Moderate	Major	Catastrophic
	Medium	Minor	Moderate	Major
	Low	Insignificant	Minor	Moderate

Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
<p>Drainage channels located in flood prone low-lying areas</p> <p>High exposure to intense rainfall and storm runoff.</p>	High	<p>High Sensitivity:</p> <p>Undersized and poorly maintained drains</p> <p>Blockage from solid waste and sediment</p>	High	<p>Catastrophic</p> <p>(Frequent flooding, infrastructure)</p>

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<p>Reliant on undersized and aging drainage systems designed for lower rainfall intensities. Increased impervious surfaces exacerbate run off volumes</p>		<p>Low Adaptive Capacity:</p> <p>Limited routine maintenance funding</p> <p>Limited climate resilient/floodproofing infrastructure.</p>		<p>damage, traffic disruption, public health risks)</p>
<p>Water & Wastewater Management</p>	<p>Sewer lines and treatment facilities exposed to floodwaters</p> <p>Water sources exposed to contamination during floods</p>	<p>Medium</p>	<p>Sensitivity:</p> <p>Aging pipelines</p> <p>Dependence on surface water sources</p> <p>High risk of contamination during over flows; pumping stations susceptible to siltation.</p>	<p>High</p>	<p>Major (Sewer overflows, water contamination, disease risk)</p>

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Solid Waste Management	Waste collection points and dumpsites exposed to flooding Waste washed into drains and rivers during storms	High	Sensitivity: Inadequate waste segregation and containment Informal dumping in flood-prone areas	High	Catastrophic (Blocked drains, worsened flooding, environmental pollution)
			Weak enforcement of waste bylaws		
Transport and Mobility	Roads, bridges, and footpaths exposed to flash floods Low-lying road sections frequently inundated	Medium	Sensitivity: Poor road drainage Erosion and pothole formation during floods	High	Major (Traffic disruption, accidents,

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Incremental road upgrades ongoing Limited redundancy in transport route		economic losses)
Energy	Power substations and distribution lines exposed to flooding Flood-induced access constraints for repairs	Medium	Sensitivity: Overhead power lines vulnerable to storm damage Limited flood protection for substations	Medium	Moderate (Power outages affecting services and businesses)
			Adaptive Capacity: National grid response mechanisms Limited local backup power systems		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Economic Infrastructure	Markets and commercial areas located in flood-prone zones Informal trading areas exposed to surface flooding	Medium	<p>Sensitivity:</p> <p>Temporary or semi-permanent structures High daily dependence on uninterrupted access</p> <p>Adaptive Capacity:</p> <p>Limited insurance coverage Low access to flood-resilient infrastructure finance</p>	High	Major (Income loss, business interruption)

Social Infrastructure	Schools and clinics exposed to surface flooding Access roads to facilities often flooded	Medium	Sensitivity: High occupancy rates Limited flood-resilient building design	Medium	Moderate (Service disruption,
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Government support systems exist Limited retrofitting and drainage improvements		health and safety risks)
Emergency Services	Emergency response routes exposed to flooding Increased emergency demand during flood events	Medium	Sensitivity: Dependence on road accessibility Limited flood-specific equipment	Medium	Moderate (Delayed response, increased flood losses)

			<p>Adaptive Capacity:</p> <p>County disaster management structures in place</p> <p>Limited early warning dissemination at local level</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Populations					
Urban Residents	Residents exposed to household and street flooding Increased health risks during flood events	Medium	<p>Sensitivity:</p> <p>Dependence on municipal services</p> <p>Exposure to contaminated floodwater</p>	High	Major

			Adaptive Capacity: Some access to information and services Limited household flood protection measures		
Informal Settlement Residents	Settlements located along rivers, floodplains, and drainage corridors.	High	Sensitivity: Poor housing materials Lack of drainage and sanitation	High	Catastrophic (Loss of property,

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Low income and insecure tenure Limited access to early warning and emergency support		displacement, health impacts)

Vulnerable and Marginalized Groups	Elderly, women, children, and persons with disabilities exposed to flood risks.	High	Sensitivity: Limited mobility and health challenges High dependency on caregivers	High	Catastrophic
			Adaptive Capacity: Limited social protection and evacuation support Dependence on informal networks		

Natural Assets

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Urban Green Infrastructure	Urban trees and green spaces exposed to waterlogging and erosion.	Medium	<p>Sensitivity:</p> <p>Degraded or compacted soils Encroachment reduces buffering capacity</p>	Medium	Moderate
			<p>Adaptive Capacity:</p> <p>Potential for restoration and expansion Community-led greening initiatives</p>		
Urban Blue Infrastructure	Rivers and streams subject to riverine flooding Riparian zones encroached and degraded	High	<p>Sensitivity:</p> <p>Reduced natural flood storage capacity Pollution from upstream and urban runoff</p>	High	Catastrophic (Severe flooding, ecosystem degradation)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			<p>Adaptive Capacity:</p> <p>Weak enforcement of riparian regulations</p> <p>Limited restoration investment</p>		
Peri-urban and Agricultural Systems	<p>Farms exposed to floodwaters and soil erosion</p> <p>Low-lying agricultural areas prone to waterlogging</p>	High	<p>Sensitivity:</p> <p>Soil erosion and crop damage</p> <p>Dependence on rain-fed agriculture</p>	High	<p>Catastrophic</p> <p>(Crop loss, food insecurity, income loss)</p>

			<p>Adaptive Capacity:</p> <p>Limited drainage and flood-resilient farming practices</p> <p>Extension services exist but under resourced</p>	
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Table 13. Exposure, Vulnerability, and Impacts of Landslides and gully erosion on Urban Elements

Hazard: Landslides and Gully erosion

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					

Stormwater Drainage	Drainage channels located on steep slopes and valley edges Concentrated runoff triggering gully formation	High	Sensitivity: Poorly lined/open drains accelerate soil erosion Discharge of runoff onto unprotected slopes	High	Catastrophic (Drain collapse, expanded gullies, downstream flooding)
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Limited slope-stabilized drainage designs Inadequate routine inspection of erosion hotspots		

Water & Wastewater Management	Pipelines and sewer lines crossing steep slopes and river valleys Treatment facilities affected by slope instability	Medium	Sensitivity: Buried pipes exposed by erosion and slope failure Sewer blockages from sediment inflow	Medium	Moderate (Service disruption, contamination risks)
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Limited slope protection around pipelines Emergency repair capacity exists but reactive		

Solid Waste Management	Informal dumping on slopes and gullies Waste accumulation destabilizing soils	Medium	Sensitivity: Waste blocks natural drainage paths Increased water infiltration and slope failure	Medium	Moderate (Accelerated erosion, environmental degradation)
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Weak enforcement of waste disposal regulations Limited engineered disposal sites		

Transport and Mobility	Roads and footpaths on steep terrain and cut slopes Bridge approaches exposed to gully erosion	High	Sensitivity: Inadequate slope stabilization and drainage Erosion undermining road foundations	High	Catastrophic (Road collapse, isolation of neighborhoods)
			Adaptive Capacity: Spot road upgrades and gabion work Limited systematic slope risk mapping		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Energy	<p>Power poles and distribution lines on unstable slopes</p> <p>Access roads to substations affected by landslides</p>	Medium	<p>Sensitivity:</p> <p>Pole foundations undermined by erosion</p> <p>Overhead lines vulnerable to slope movement</p>	Medium	<p>Moderate</p> <p>(Power outages, repair delays)</p>
			<p>Adaptive Capacity:</p> <p>National utility response mechanisms</p> <p>Limited proactive slope stabilization</p>		
Economic Infrastructure	<p>Markets and small enterprises near valley edges and slopes</p> <p>Peri-urban workshops exposed to slope instability</p>	High	<p>Sensitivity:</p> <p>Informal structures with shallow foundations</p> <p>Limited structural reinforcement</p>	High	<p>Catastrophic</p> <p>(Business losses, asset destruction)</p>

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			<p>Adaptive Capacity:</p> <p>Low insurance coverage</p> <p>Limited access to relocation or retrofitting finance</p>		
Social Infrastructure	Facilities located near steep slopes and eroding drainage lines.	Medium	<p>Sensitivity:</p> <p>High occupancy and safety risks</p> <p>Buildings not designed for slope instability.</p>	Medium	Moderate (Service disruption, safety risks)
			<p>Adaptive Capacity:</p> <p>Some government support for repairs</p> <p>Limited preventive slope reinforcement</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Emergency Services	Emergency access routes prone to landslides Increased rescue demand during heavy rainfall	Medium	Sensitivity: Dependence on road access Limited landslide rescue equipment	High	Moderate (Delayed response, increased casualties)
			Adaptive Capacity: County disaster response structures exist Limited early warning for slope failure		
Populations					

Urban Residents	Households located near slopes, gullies, and cut embankments.	Medium	Sensitivity: Housing damage from slope failure Safety risks during heavy rainfall	Medium	Moderate
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Some access to information and municipal support Limited household slope protection measures		

Informal Settlement Residents	Settlements on steep slopes, riverbanks, and gully edges.	High	Sensitivity: Poor-quality housing materials Lack of drainage and slope stabilization	High	Catastrophic (Loss of homes, displacement, fatalities)
			Adaptive Capacity: Low income and insecure land tenure Limited relocation options		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Vulnerable and Marginalized Groups	Elderly, women, children, and PWDs in landslide-prone areas.	High	Sensitivity: Limited mobility and evacuation capacity Health vulnerabilities	High	Catastrophic

Adaptive Capacity:

Limited social protection and targeted evacuation plans

Dependence on informal support systems

Natural Assets

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Urban Green Infrastructure	Vegetated slopes and open spaces to erosion.	Medium	Sensitivity: Vegetation loss increases slope instability Soil compaction from development	Medium	Moderate

			<p>Adaptive Capacity:</p> <p>High potential for bio-engineering and re-vegetation</p> <p>Community greening initiatives</p>		
Urban Blue Infrastructure	Riverbanks and riparian corridors exposed to gully erosion.	Medium	<p>Sensitivity:</p> <p>Encroachment weakens bank stability</p> <p>Increased sediment loads from upstream</p>	High	Major (Channel widening,

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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			<p>Adaptive Capacity:</p> <p>Weak enforcement of riparian protection</p> <p>Limited riverbank stabilization projects</p>		downstream flooding)
Peri-urban and Agricultural Systems	Farms on steep slopes exposed to soil erosion and landslides.	High	<p>Sensitivity:</p> <p>Loss of topsoil and crops</p> <p>Limited terracing and soil conservation</p>	High	Catastrophic (Land degradation, food and income losses)
			<p>Adaptive Capacity:</p> <p>Some extension services for soil conservation</p> <p>Low adoption of climate-smart practices</p>		

Figure 8. Exposure, Vulnerability, and Impacts of Drought and water stress on Urban Elements

Hazard: Drought and Water stress

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Stormwater Drainage	Prolonged dry periods reduce base flows in drainage channels Sediment accumulation and cracking of drains during drought	Medium	<p>Sensitivity:</p> <p>Dry, compacted channels reduce future infiltration</p> <p>Increased damage when rains return after drought</p>	Medium	Moderate (Reduced system efficiency, increased post drought flood risk)
			<p>Adaptive Capacity:</p> <p>Limited integration of water harvesting in drainage design</p> <p>Minimal maintenance during dry periods</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Water & Wastewater Management	Reduced river flows and groundwater recharge Increased abstraction pressure during droughts	High	Sensitivity: High dependence on surface water sources Limited storage and reuse capacity	Medium	Major (Water shortages, sanitation failures, public health risks)
			Adaptive Capacity: Water rationing plans exist Limited alternative sources (reuse, rainwater harvesting)		
Solid Waste Management	Increased waste accumulation due to reduced water for cleaning Dry conditions increase dust and waste dispersion	Medium	Sensitivity: Organic waste decomposes faster in heat Open dumping exacerbated by dry conditions	Medium	Moderate (Public health risks, environmental degradation)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			<p>Adaptive Capacity:</p> <p>Limited mechanized cleaning</p> <p>Weak waste segregation systems</p>		
Transport and Mobility	<p>Roads exposed to dust, surface cracking, and material degradation</p> <p>Reduced water availability for construction and maintenance</p>	Medium	<p>Sensitivity:</p> <p>Unpaved roads degrade rapidly in dry conditions</p> <p>Heat stress affects road surfaces</p> <p>Adaptive Capacity:</p> <p>Routine maintenance programs exist</p> <p>Limited climate-resilient road materials</p>	Medium	<p>Moderate</p> <p>(Increased maintenance costs, reduced safety)</p>

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Energy	<p>Hydropower generation affected by reduced river flows</p> <p>Increased electricity demand for pumping and cooling</p>	Medium	<p>Sensitivity:</p> <p>Dependence on national hydropower mix</p> <p>Limited local renewable diversification</p> <hr/> <p>Adaptive Capacity:</p> <p>National grid balancing mechanisms</p> <p>Growing solar uptake but still limited</p>	Medium	<p>Moderate</p> <p>(Power shortages, increased costs)</p>

Economic Infrastructure	Water-dependent businesses (food processing, hospitality) exposed to shortages Markets affected by reduced supply and higher costs	Medium	Sensitivity: High dependence on reliable water supply. Informal enterprises lack storage capacity.	High	Major (Business losses, reduced livelihoods)
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Limited insurance and water efficiency investments Low access to climate finance		

Social Infrastructure	Schools and hospitals affected by water shortages Increased demand for sanitation during drought	High	Sensitivity: High water demand facilities Limited on-site storage	Medium	Major (Service disruption, hygiene risks)
			Adaptive Capacity: Emergency water trucking sometimes available Limited rainwater harvesting infrastructure		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Emergency Services	Increased demand during drought-related health and fire incidents Limited water for firefighting	Medium	Sensitivity: Dependence on municipal water supply Increased wildfire risk during drought	Medium	Moderate
			Adaptive Capacity: Emergency response structures exist Limited dedicated water reserves		

Populations

Urban Residents	Household water rationing and rising water costs Increased heat and hygiene stress	Medium	Sensitivity: Dependence on piped water Health impacts from reduced hygiene	High	Major
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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			<p>Adaptive Capacity:</p> <p>Some access to storage tanks and information</p> <p>Limited household rainwater harvesting</p>		
Informal Settlement Residents	<p>High exposure to water scarcity and price shocks</p> <p>Reliance on vendors and unsafe water sources</p>	Medium	<p>Sensitivity:</p> <p>Poor sanitation and overcrowding</p> <p>Limited water storage</p>	High	<p>Major</p> <p>(Health crises, livelihood losses)</p>
			<p>Adaptive Capacity:</p> <p>Low income and insecure tenure</p> <p>Limited access to alternative water sources</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Vulnerable and Marginalized Groups	Elderly, women, children, and PWDs disproportionately affected by water scarcity.	Medium	<p>Sensitivity:</p> <p>Higher health and care needs</p> <p>Increased burden of water collection</p>	High	Major
			<p>Adaptive Capacity:</p> <p>Limited social protection and targeted support</p> <p>Dependence on informal coping mechanisms</p>		
Natural Assets					

Urban Green Infrastructure	Urban trees and parks exposed to prolonged moisture stress.	High	Sensitivity: Specific site species grown Limited irrigation during drought	Low	Moderate (Loss of cooling, urban)
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Potential for drought-tolerant species Limited maintenance budget		heat amplification)
Urban Blue Infrastructure	Rivers and wetlands experience reduced flows and drying.	High	Sensitivity: Over-abstraction and pollution Reduced ecological resilience	Medium	Major (Ecosystem degradation, water insecurity)

			<p>Adaptive Capacity:</p> <p>Weak enforcement of abstraction controls</p> <p>Limited restoration efforts</p>		
Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Peri-urban and Agricultural Systems	<p>Rain-fed farming exposed to prolonged dry spells</p> <p>Reduced pasture and crop productivity</p>	High	<p>Sensitivity:</p> <p>Dependence on rainfall</p> <p>Limited irrigation infrastructure</p> <hr/> <p>Adaptive Capacity:</p> <p>Some extension services available</p> <p>Low uptake of drought-resilient crops</p>	Medium	<p>Major</p> <p>(Food insecurity, income loss)</p>

Hazard: Heat Stress.

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					
Stormwater Drainage	Concrete-lined drains exposed to prolonged high temperatures Dry conditions reduce shading and increase thermal stress	Low	Sensitivity: Thermal cracking and reduced lifespan of concrete structures Reduced infiltration capacity during dry periods	Medium	Minor (Infrastructure degradation, increased repair needs)

			<p>Adaptive Capacity:</p> <p>Limited use of green or shaded drainage designs</p> <p>Minimal heat-specific maintenance planning</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Water & Wastewater Management	<p>Increased evaporation from reservoirs and storage tanks</p> <p>Higher water demand during hot periods</p>	Medium	<p>Sensitivity:</p> <p>Limited storage and cooling of treatment facilities</p> <p>Increased stress on pumping and distribution systems</p>	Medium	<p>Moderate</p> <p>(Water shortages, service interruptions)</p>

			<p>Adaptive Capacity:</p> <p>Some demand-management measures exist</p> <p>Limited reuse and rainwater harvesting uptake</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Solid Waste Management	<p>Waste collection and disposal sites exposed to high temperatures</p> <p>Faster decomposition of organic waste</p>	Medium	<p>Sensitivity:</p> <p>Increased odors, pests, and health risks</p> <p>Fire risk at dumpsites during hot, dry periods</p>	Medium	<p>Moderate</p> <p>(Public health concerns, environmental degradation)</p>

			<p>Adaptive Capacity:</p> <p>Limited waste covering and cooling measures</p> <p>Weak enforcement of waste management standards</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Transport and Mobility	Roads and pedestrian infrastructure exposed to high surface temperatures Public transport users exposed to heat stress	Medium	<p>Sensitivity:</p> <p>Asphalt softening and surface deformation</p> <p>Limited shading along walkways and stops</p>	Medium	Moderate (Reduced mobility, safety risks)

Adaptive Capacity:

Incremental road upgrades underway
Minimal use of heat-resilient materials

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Energy	Increased electricity demand for cooling and water pumping Heat exposure of transformers and substations	Low	Sensitivity: Overloading of power distribution networks Reduced efficiency of equipment at high temperatures	Medium	Minor (Power outages, increased energy costs)

			<p>Adaptive Capacity:</p> <p>National grid balancing mechanisms</p> <p>Limited distributed renewable and storage system</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Economic Infrastructure	<p>Markets, workshops, and informal enterprises exposed to extreme heat</p> <p>Outdoor economic activities highly affected</p>	Medium	<p>Sensitivity:</p> <p>Heat reduces labor productivity</p> <p>Informal structures offer little thermal protection</p>	Medium	<p>Moderate</p> <p>(Income loss, reduced productivity)</p>

			<p>Adaptive Capacity:</p> <p>Limited cooling and shading investments</p> <p>Low insurance and climate finance access</p>		
Social Infrastructure	<p>Schools and health facilities exposed to overheating</p> <p>High indoor temperatures during heatwaves</p>	Medium	<p>Sensitivity:</p> <p>Overcrowded classrooms and wards</p> <p>Limited ventilation and cooling systems</p>	Medium	<p>Moderate</p> <p>(Health risks, learning disruptions)</p>

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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			Adaptive Capacity: Some passive ventilation designs Limited retrofitting and cooling budgets		
Emergency Services	Increased demand during heat-related illnesses and fires Outdoor responders exposed to heat stress	Medium	Sensitivity: Physical strain on personnel Dependence on reliable water and power	Medium	Moderate
			Adaptive Capacity: Existing emergency response structures Limited heat-specific response planning		
Populations					

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Urban Residents	Exposure to higher daytime and nighttime temperatures Urban heat-island effects in dense areas	High	Sensitivity: Heat-related illnesses Increased water and energy needs	Medium	Major
			Adaptive Capacity: Some access to cooling and information Limited household greening and insulation		
Informal Settlement Residents	Densely built settlements with poor ventilation Limited tree cover and shading	High	Sensitivity: Heat-trapping housing materials Overcrowding and poor sanitation	Medium	Major (Severe health impacts,

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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			<p>Adaptive Capacity:</p> <p>Low income and limited access to cooling</p> <p>Insecure tenure limits upgrading</p>		reduced livelihoods)
Vulnerable and Marginalized Groups	Elderly, children, pregnant women, PWDs exposed to extreme heat.	High	<p>Sensitivity:</p> <p>Reduced thermoregulation and health conditions</p> <p>Dependence on caregivers</p>	Medium	Major
			<p>Adaptive Capacity:</p> <p>Limited targeted heat-health interventions</p> <p>Reliance on informal support networks</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Natural Assets					
Urban Green Infrastructure	Urban trees and green spaces exposed to heat and moisture stress.	Medium	<p>Sensitivity:</p> <p>Limited irrigation and maintenance Loss of canopy cover increases heat-island effects</p> <p>Adaptive Capacity:</p> <p>Potential for urban greening and shade expansion Community tree-planting initiatives</p>	Medium	Moderate (Reduced cooling services, increased urban heat)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Urban Blue Infrastructure	Reduced river flows and increased water temperatures.	High	<p>Sensitivity:</p> <p>Pollution and over-abstraction reduce cooling capacity</p> <p>Reduced ecological resilience</p>	Medium	Moderate (Loss of cooling and ecosystem services)
Peri-urban and Agricultural Systems	Crops and livestock exposed to heat stress Increased evapotranspiration rates	High	<p>Adaptive Capacity:</p> <p>Limited restoration and protection efforts</p> <p>Weak enforcement of riparian buffers</p>	Medium	Major (Food insecurity, income losses)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: Some extension services available Low uptake of heat-tolerant practices		

Table 14. Exposure, Vulnerability, and Impacts of Change in precipitation patterns on Urban Elements

Hazard: Change in precipitation patterns

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Stormwater Drainage	Drainage systems exposed to intense short-duration rainfall events High runoff variability between dry spells and heavy rains	Medium	<p>Sensitivity:</p> <p>Undersized drains not designed for peak intensities</p> <p>Sedimentation and damage after long dry periods</p>	High	Major (Flash flooding, infrastructure damage)
			<p>Adaptive Capacity:</p> <p>Limited climate-resilient and flexible drainage design</p> <p>Infrequent maintenance and limited monitoring</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Water & Wastewater Management	Water intakes exposed to both flooding and reduced base flows Sewer systems stressed by sudden inflow peaks	Medium	Sensitivity: Combined storm water-sewer interactions in some areas Treatment processes disrupted by fluctuating volumes	High	Major (Overflows, contaminations supply interruptions)
			Adaptive Capacity: Some emergency operational procedures exist Limited storage and flow-balancing infrastructure		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Solid Waste Management	Waste sites exposed to flooding during heavy rains Dry periods increase waste accumulation in drains	Medium	Sensitivity: Poor containment of waste Waste washed into drains during intense rainfall	High	Major (Blocked drainage, amplified flood risk)
			Adaptive Capacity: Limited waste segregation and transfer facilities Weak enforcement of disposal regulations		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Transport and Mobility	Roads and footpaths exposed to washouts and erosion Bridges affected by fluctuating river levels	Medium	Sensitivity: Poor road drainage and slope protection Rapid surface degradation after heavy storms	High	Major (Disrupted mobility, economic losses)
			Adaptive Capacity: Periodic road upgrades ongoing Limited redundancy in transport routes		
Energy	Power infrastructure exposed to storm damage and flooding Variable rainfall affects hydropower generation	Medium	Sensitivity: Overhead lines vulnerable to storms Dependence on national hydropower mix	Medium	Moderate (Outages, increased costs)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: National grid balancing mechanisms Limited local distributed generation		
Economic Infrastructure	Markets and businesses exposed to both flooding and water scarcity Informal trading areas highly sensitive to rainfall variability	Medium	Sensitivity: Temporary structures vulnerable to damage Supply chains disrupted by weather extremes	High	Major (Business interruption, income loss)

			<p>Adaptive Capacity:</p> <p>Low insurance coverage</p> <p>Limited access to climate-resilient infrastructure finance</p>	
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Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Social Infrastructure	Facilities affected by flooding during heavy rains and shortages during dry spells.	High	<p>Sensitivity:</p> <p>High occupancy and service demand</p> <p>Limited flexible water and drainage systems</p>	Medium	Major (Service disruption, health risks)

			Adaptive Capacity: Government support mechanisms exist Limited retrofitting and storage capacity		
Emergency Services	Increased emergency demand during extreme rainfall events Access routes exposed to flooding and erosion	Medium	Sensitivity: Dependence on road accessibility Limited specialized equipment	Medium	Moderate

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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			<p>Adaptive Capacity:</p> <p>County disaster response structures exist</p> <p>Limited early warning and local preparedness</p>		
Populations					
Urban Residents	Exposure to both flash floods and intermittent water shortages.	Medium	<p>Sensitivity:</p> <p>Health risks from contaminated water</p> <p>Property damage from flooding</p>	Medium	Moderate
			<p>Adaptive Capacity:</p> <p>Some access to information and services</p> <p>Limited household-level adaptation</p>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Informal Settlement Residents	Settlements in flood-prone and poorly drained areas.	High	Sensitivity: Poor housing quality and lack of services High exposure to floodwaters and sanitation failures	Medium	Major
			Adaptive Capacity: Low income and insecure tenure Limited early warning and coping capacity		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Vulnerable and Marginalized Groups	Elderly, children, women, and PWDs exposed to rainfall extremes.	High	Sensitivity: health Limited mobility and vulnerabilities Dependence on caregivers	Medium	Major
			Adaptive Capacity: Limited targeted social protection Reliance on informal support networks		

Natural Assets

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
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Urban Green Infrastructure	Green spaces expose to both waterlogging and drought stress.	Medium	<p>Sensitivity:</p> <p>Poor soil structure and limited maintenance</p> <p>Loss of vegetation cover during extremes</p>	Medium	Moderate (Reduced flood regulation and cooling services)
			<p>Adaptive Capacity:</p> <p>Potential for nature-based solutions</p> <p>Community greening initiatives</p>		
Urban Blue Infrastructure	Rivers experience rapid flow fluctuations Increased erosion and sedimentation	High	<p>Sensitivity:</p> <p>Encroachment reduces buffering capacity</p> <p>Pollution during high-flow events</p>	Medium	Major (Flooding, ecosystem degradation)

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			<p>Adaptive Capacity:</p> <p>Weak enforcement of riparian protection</p> <p>Limited restoration investment</p>		
Peri-urban and Agricultural Systems	Rain-fed agriculture exposed to erratic rainfall patterns.	Medium	<p>Sensitivity:</p> <p>Crop failure from both drought and flooding</p> <p>Soil erosion on slopes</p> <hr/> <p>Adaptive Capacity:</p> <p>Extension services exist</p> <p>Limited irrigation and water harvesting</p>	High	Major (Food insecurity, income loss)

4. Climate Risk Assessment

This section synthesizes the findings from the hazard assessment and the exposure and vulnerability analysis to determine the overall climate risks facing Nanyuki Municipality. Climate risk is assessed by combining the severity of current and future climate hazards with the magnitude of their impacts on urban infrastructure, populations, and natural assets, under both current conditions and future climate scenarios.

		Hazard Level		
		Low	Medium	High
Impact Level	Catastrophic	High	Very High	Very High
	Major	Medium	High	Very High
	Moderate	Low	Medium	High
	Minor	Low	Low	Medium
	Insignificant	Very Low	Low	Low

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.

Current and Future Climate Risks on Urban Elements

		Time Horizon & Climate Scenario	Current	2030	2050	2070	2100
		Hazard Level	Medium	High	High	High	Very High
Categories	Impact	Risk Levels					
		Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5	
Infrastructure & Services							

Stormwater Drainage	Overtopping, blockage, localized flash flooding	Very High	Very High	Very High	Very High	Very High
Water & Wastewater Management	Flooded sewer lines, contamination of water sources	High	Very High	Very High	Very High	Very High
Solid Waste Management	Waste washed into drains and rivers, worsening floods	Very High	Very High	Very High	Very High	Very High
Transport and Mobility	Road flooding, bridge overtopping, traffic disruption	High	Very High	Very High	Very High	Very High
Energy	Power outages, substation flooding	Medium	High	High	High	High
Economic Infrastructure	Disruption to markets, SMEs, industrial areas	High	Very High	Very High	Very High	Very High
Social Infrastructure	Flooding of schools, health facilities	Medium	High	High	High	High

Emergency Services	Reduced access and response time during floods	Medium	High	High	High	High
Populations						
Urban Residents	Property damage, health risks, displacement	High	Very High	Very High	Very High	Very High
Informal Settlement Residents	Loss of shelters, high exposure along riverbanks	Very High	Very High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	Increased disease risk, livelihood loss	Very High	Very High	Very High	Very High	Very High
Natural Assets						
Urban Green Infrastructure	Erosion, degradation, loss of flood buffering	Medium	High	High	High	High
Urban Blue Infrastructure	Riverbank erosion, wetland degradation	Very High	Very High	Very High	Very High	Very High

Peri-urban and Agricultural Systems	Crop damage, soil erosion, livelihood loss	Very High	Very High	Very High	Very High	Very High
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Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Hazard Level	Medium	Medium	High	High	High

Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100

Infrastructure & Services

Stormwater Drainage	Gully formation, collapse drains of	Very High	Very High	Very High	Very High	Very High
Water & Wastewater Management	Pipe breakage, contamination	Medium	Medium	High	High	High

Solid Waste Management	Waste exposed and washed into gullies	Medium	Medium	High	High	High
Transport and Mobility	Road subsidence, landslide blockages	Very High	Very High	Very High	Very High	Very High

Energy	Damage to poles, buried cables	Medium	Medium	High	High	High
Economic Infrastructure	Damage to markets, workshops, SMEs	Very High	Very High	Very High	Very High	Very High
Social Infrastructure	Damage to schools, health centers	Medium	Medium	High	High	High
Emergency Services	Restricted access during slope failures	Medium	Medium	High	High	High
Populations						
Urban Residents	Property damage, safety risks	Medium	Medium	High	High	High

Informal Settlement Residents	House collapse, displacement	Very High	Very High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	Loss of shelter and livelihoods	Very High	Very High	Very High	Very High	Very High
Natural Assets						
Urban Green Infrastructure	Vegetation loss, slope instability	Medium	Medium	High	High	High
Urban Blue Infrastructure	Sedimentation of streams	High	High	Very High	Very High	Very High
Peri-urban and Agricultural Systems	Soil loss, reduced productivity	Very High	Very High	Very High	Very High	Very High

	Time & Horizon Climate Scenario	Current	2030	2050	2070	2100
	Hazard Level	Medium	Medium	High	High	Very High
Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100

Infrastructure & Services						
Stormwater Drainage	Reduced base flows, sediment buildup	Medium	Medium	High	High	High
Water & Wastewater Management	Water shortages, reduced treatment efficiency	High	High	Very High	Very High	Very High

Solid Waste Management	Reduced cleaning capacity, public health risks	Medium	Medium	High	High	High
Transport and Mobility	Dust, reduced road durability	Medium	Medium	High	High	High
Energy	Reduced hydropower reliability, cooling needs	Medium	Medium	High	High	High

Economic Infrastructure	Reduced productivity, higher operating costs	High	High	Very High	Very High	Very High
Social Infrastructure	Water shortages in schools & hospitals	High	High	Very High	Very High	Very High
Emergency Services	Limited water for firefighting	Medium	Medium	High	High	High
Populations						
Urban Residents	Intermittent supply, increased costs	High	High	Very High	Very High	Very High
Informal Settlement Residents	Acute shortages, reliance on unsafe sources	High	High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	Health risks, reduced coping capacity	High	High	Very High	Very High	Very High
Natural Assets						

Urban Green Infrastructure	Vegetation stress, loss of cooling	Medium	Medium	High	High	High
Urban Blue Infrastructure	Reduced flows, degraded water quality	High	High	Very High	Very High	Very High
Peri-urban and Agricultural Systems	Crop losses, livestock stress	High	High	Very High	Very High	Very High

Time Horizon & Climate Scenario	Current	2030	2050	2070	2100
Hazard Level	Low	Medium	Medium	High	High

Categories	Impact	Risk Levels				
		Current	2030	2050	2070	2100
Infrastructure & Services						

Stormwater Drainage	Thermal stress on structures, low flows	Low	Low	Low	Medium	Medium
Water & Wastewater Management	Higher demand, treatment stress	Low	Medium	Medium	High	High
Solid Waste Management	Oduor, worker exposure, health risks	Low	Medium	Medium	High	High
Transport and Mobility	Road surface degradation, heat exposure	Low	Medium	Medium	High	High
Energy	Increased cooling demand, outages	Low	Low	Low	Medium	Medium
Economic Infrastructure	Productivity loss, heat-related downtime	Low	Medium	Medium	High	High
Social Infrastructure	Overheated schools and health facilities	Low	Medium	Medium	High	High

Emergency Services	Increased heat-related emergencies	Low	Medium	Medium	High	High
Populations						
Urban Residents	Discomfort, health stress	Medium	High	High	Very High	Very High
Informal Settlement Residents	Severe indoor heat, dehydration	Medium	High	High	Very High	Very High
Vulnerable and Marginalized Groups	Heat illness, mortality risk	Medium	High	High	Very High	Very High
Natural Assets						
Urban Green Infrastructure	Heat stress, reduced cooling capacity	Low	Medium	Medium	High	High
Urban Blue Infrastructure	Higher evaporation, lower cooling effect	Low	Medium	Medium	High	High
Peri-urban and Agricultural Systems	Crop stress, reduced yields	Medium	High	High	Very High	Very High

		Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
		Hazard Level	Medium	High	High	High	Very High
Categories	Impact	Risk Levels					
		Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5	
Infrastructure & Services							
Stormwater Drainage	Overtopping during storms; inefficiency in dry periods	High	Very High	Very High	Very High	Very High	
Water & Wastewater Management	Treatment overload and low-flow stress	High	Very High	Very High	Very High	Very High	
Solid Waste Management	Waste mobilization during storms	High	Very High	Very High	Very High	Very High	
Transport and Mobility	Flooded roads, erosion, delays	High	Very High	Very High	Very High	Very High	

Energy	Disruption from storms and erosion	Medium	High	High	High	High
Economic Infrastructure	Business interruptions, damage	High	Very High	Very High	Very High	Very High
Social Infrastructure	School and health facility disruption	High	Very High	Very High	Very High	Very High
Emergency Services	Increased demand, reduced access	Medium	High	High	High	High
Populations						
Urban Residents	Property damage, safety risks	Medium	High	High	High	High
Informal Settlement Residents	Flooding, landslide exposure	High	Very High	Very High	Very High	Very High
Vulnerable and Marginalized Groups	Health risks, livelihood loss	Medium	High	High	High	High
Natural Assets						
Urban Green Infrastructure	Erosion and vegetation stress	Medium	High	High	High	High

Urban Blue Infrastructure	Flash flooding, sedimentation	Medium	High	High	High	High
Peri-urban and Agricultural Systems	Crop losses, soil erosion	Medium	High	High	High	High

Overall risk assessment indicates there is Very High Risk of Flooding impacts on informal settlements, drainage, and transport (2050–2100, SSP5-8.5). High Risk of Landslides affecting roads and settlements on steep slopes and Medium Risk of Drought impacts on water supply and agriculture (current to mid-term).

5. Strategic Actions

Flood Risk Reduction

- Improvement and expansion of stormwater drainage systems
- Regular desilting and solid waste management
- Protection and enforcement of riparian reserves

Water Security and Drought Resilience

- Rainwater harvesting in public facilities
- Catchment protection and conservation
- Promotion of water-use efficiency

Heat and Urban Resilience

- Urban greening and tree planting
- Climate-responsive building designs

- Provision of shaded public spaces

Institutional and Community Measures

- Mainstreaming climate risk into municipal planning
- Community awareness and preparedness
- Strengthening early warning and response systems

Major priority

- Strengthening water storage and conservation systems.
- Climate-proofing drainage and transport infrastructure.
- Restoring degraded ecosystems and protecting riparian buffers.
- Integrating climate risk screening into municipal planning and budgeting

Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
Infrastructure & Services			
Stormwater Drainage	<ul style="list-style-type: none"> • Localized flooding due to undersized and blocked drains. • Erosion of open channels during heavy rains. 	<ul style="list-style-type: none"> • Increased pluviial flooding from higher rainfall intensity • Frequent drain overflows and infrastructure damage. 	<ul style="list-style-type: none"> • Severe and recurrent urban flooding • Structural failure of drainage systems without major upgrades

Water & Wastewater Management	<ul style="list-style-type: none"> Seasonal water shortages Sewer overflows during heavy rainfall 	<ul style="list-style-type: none"> Reduced water availability due to prolonged droughts Increased contamination risks from flooding 	<ul style="list-style-type: none"> Chronic water stress Failure of aging water and wastewater systems under extreme events
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Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
Solid Waste Management	<ul style="list-style-type: none"> Waste clogging drainage systems Flooding around dumpsites 	<ul style="list-style-type: none"> Increased waste generation and flood-related waste dispersal 	<ul style="list-style-type: none"> Persistent environmental pollution Flooded and unstable waste disposal sites
Transport and Mobility	<ul style="list-style-type: none"> Flooded roads during heavy rainfall Landslide risks on steep sections 	<ul style="list-style-type: none"> Increased road washouts and traffic disruption 	<ul style="list-style-type: none"> Major transport network failures Reduced connectivity and mobility reliability
Energy	<ul style="list-style-type: none"> Occasional power outages during storms 	<ul style="list-style-type: none"> Increased disruption from storms and heat stress on infrastructure 	<ul style="list-style-type: none"> Chronic instability of energy supply Damage to transmission and distribution systems

Economic Infrastructure	<ul style="list-style-type: none"> Weather-related damage to markets and SMEs 	<ul style="list-style-type: none"> Reduced productivity due to heat stress and flooding 	<ul style="list-style-type: none"> Long-term economic losses Decline in urban competitiveness
Social Infrastructure	<ul style="list-style-type: none"> Flooding of schools and health facilities in low-lying areas 	<ul style="list-style-type: none"> Increased service disruption from extreme events 	<ul style="list-style-type: none"> Structural damage and relocation needs for key facilities

Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
Emergency Services	<ul style="list-style-type: none"> Limited capacity during flood events 	<ul style="list-style-type: none"> Increased demand for disaster response 	<ul style="list-style-type: none"> Overstretched emergency services High disaster response costs
Populations			
Urban Residents	<ul style="list-style-type: none"> Exposure to flooding and water shortages 	<ul style="list-style-type: none"> Increased health risks (waterborne and heat-related diseases) 	<ul style="list-style-type: none"> Declining urban livability Increased displacement risk
Informal Settlement Residents	<ul style="list-style-type: none"> High exposure to floods and poor sanitation 	<ul style="list-style-type: none"> Intensified flooding and disease outbreaks 	<ul style="list-style-type: none"> Severe vulnerability, displacement, and livelihood loss
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> Limited adaptive capacity 	<ul style="list-style-type: none"> Increased poverty and health risks 	<ul style="list-style-type: none"> Deepened social inequality and chronic vulnerability

Natural Assets				
Urban Infrastructure	Green	<ul style="list-style-type: none"> Degradation of green spaces 	<ul style="list-style-type: none"> Reduced ecosystem services (cooling, flood buffering) 	<ul style="list-style-type: none"> Loss of urban green cover Increased urban heat island effects
Urban Infrastructure	Blue	<ul style="list-style-type: none"> Pollution of rivers and wetlands 	<ul style="list-style-type: none"> Increased flooding and reduced water quality 	<ul style="list-style-type: none"> Degraded river systems Loss of natural flood regulation
		List of Key Hazards		
Category		Current	Mid-term (2050)	Long-term (2100)
Peri-urban and Agricultural Systems		<ul style="list-style-type: none"> Variable rainfall affecting productivity 	<ul style="list-style-type: none"> Frequent droughts and crop failures 	<ul style="list-style-type: none"> Unsustainable agriculture Food insecurity and land degradation

Climate Adaptation and Resilience Solutions

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Infrastructure & Services			
Stormwater Drainage	<ul style="list-style-type: none"> • Desilt and rehabilitate existing drains • Enforce solid waste control in drainage corridors 	<ul style="list-style-type: none"> • Upgrade drainage capacity to climate resilient standards • Introduce nature-based drainage (swales, retention ponds) 	<ul style="list-style-type: none"> • Integrated urban flood management system • City-wide green-blue infrastructure network
Water & Wastewater Management	<ul style="list-style-type: none"> • Repair leakages and illegal connections • Protect water sources and intakes 	<ul style="list-style-type: none"> • Expand water storage and diversify sources • Climate-proof sewer and wastewater systems 	<ul style="list-style-type: none"> • Integrated water resources management • Circular water reuse and smart water systems
Solid Waste Management	<ul style="list-style-type: none"> • Improve waste collection coverage • Prevent dumping in rivers and drains 	<ul style="list-style-type: none"> • Develop engineered landfills and transfer stations • Promote recycling and waste segregation 	<ul style="list-style-type: none"> • Circular economy approach • Zero-waste and resource recovery systems

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Transport and Mobility	<ul style="list-style-type: none"> • Routine maintenance of roads and culverts • Improve drainage along transport corridors 	<ul style="list-style-type: none"> • Climate-resilient Road design and materials • Improve public transport systems 	<ul style="list-style-type: none"> • Climate-proofed transport network • Low-carbon and resilient mobility systems
Energy	<ul style="list-style-type: none"> • Protect substations from flooding • Improve maintenance of distribution lines 	<ul style="list-style-type: none"> • Promote decentralized renewable energy (solar) • Improve grid resilience 	<ul style="list-style-type: none"> • Smart, resilient, and low-carbon energy systems • Energy storage and micro grids
Economic Infrastructure	<ul style="list-style-type: none"> • Flood-proof markets and business areas • Climate risk awareness for SMEs 	<ul style="list-style-type: none"> • Relocate or retrofit high-risk economic assets • Support climate-resilient local enterprises 	<ul style="list-style-type: none"> • Climate-resilient urban economy • Diversified and low-carbon economic base
Social Infrastructure	<ul style="list-style-type: none"> • Improve drainage and access around schools and health facilities • Emergency preparedness plans 	<ul style="list-style-type: none"> • Retrofit public buildings for flood and heat resilience • Decentralize critical services 	<ul style="list-style-type: none"> • Relocate or redesign facilities away from high-risk zones • Resilient service delivery systems
Emergency Services	<ul style="list-style-type: none"> • Strengthen early warning and response coordination • Train local disaster response teams 	<ul style="list-style-type: none"> • Upgrade emergency infrastructure and equipment • Integrate climate risk into disaster planning 	<ul style="list-style-type: none"> • Fully integrated disaster risk management system • Predictive risk and response systems

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Populations			
Urban Residents	<ul style="list-style-type: none"> • Public awareness on flood and heat risks • Household rainwater harvesting 	<ul style="list-style-type: none"> • Improve access to climate-resilient housing • Urban cooling initiatives 	<ul style="list-style-type: none"> • Climate-resilient neighborhoods • Improved urban livability and safety
Informal Settlement Residents	<ul style="list-style-type: none"> • Improve drainage and sanitation • Flood risk mapping and early warning 	<ul style="list-style-type: none"> • In-situ upgrading of informal settlements • Secure tenure and basic services 	<ul style="list-style-type: none"> • Planned relocation from high-risk zones • Inclusive, resilient housing development
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> • Targeted social protection and health outreach • Inclusive disaster preparedness 	<ul style="list-style-type: none"> • Livelihood diversification and skills training • Improved access to services 	<ul style="list-style-type: none"> • Reduced vulnerability through inclusive development • Intergenerational resilience building
Natural Assets			
Urban Green Infrastructure	<ul style="list-style-type: none"> • Protect existing green spaces • Urban tree planting 	<ul style="list-style-type: none"> • Expand green corridors and parks • Integrate green spaces into land-use planning 	<ul style="list-style-type: none"> • City-wide green network • Enhanced urban cooling and flood regulation

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Urban Blue Infrastructure	<ul style="list-style-type: none"> • River clean-ups and riparian protection • Control pollution sources 	<ul style="list-style-type: none"> • Restore wetlands and river buffers • Integrate rivers into flood management 	<ul style="list-style-type: none"> • Fully restored river systems • Long-term ecosystem-based flood management
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> • Promote water-efficient farming • Soil and water conservation measures 	<ul style="list-style-type: none"> • Climate-smart agriculture • Diversified crops and irrigation systems 	<ul style="list-style-type: none"> Resilient peri-urban food systems Sustainable land and water management

CLIMATE CHANGE ADAPTATION

Institutional Framework for Adaptation

The Government of Kenya has developed a policy and institutional framework to support the country reach its low carbon, climate resilient goals. The government has implemented a number of actions in the National Climate Change Action Plan 2013–2017, including improved drought management and the promotion of renewable energy. The Ministry of Planning and Devolution has included indicators to track progress in mainstreaming climate change in its Second Handbook of National Reporting.⁸⁸ The National Climate Change Council, established in 2016 and housed in the Ministry of Environment and Forestry, is responsible for the coordination of climate change actions, including mainstreaming climate change in national and county budgets, plans and programs. The Kenya Meteorological Department, a semiautonomous government department, is responsible for generating national and sub-national information regarding forecasts, seasonal variability, early warnings and agrometeorological bulletins. This information is delivered to the general public and to the climate Change Council and key government institutions such as the Disaster Risk Management Authority. The drafted Climate Change Framework Policy and a National Policy on Climate Finance are expected to provide guidance on mainstreaming to national departments and country governments. To support climate change adaptation, mitigation and resilience pathways, the country can access climate financing through the National Environment Management Authority, which is a National Implementing Entity for the Adaptation Fund and accredited by the UNFCCC Green climate fund.

Policy Framework for Adaptation

Kenya has served as a leader in addressing climate change issues nationally and across the region and was one of the first countries in Africa to enact a comprehensive law and policy to guide national and subnational climate action. The Climate Change Act and the National

Climate Change Policy Framework of 2016 provide guidance

for low-carbon and climate-resilient development. These efforts are reinforced by the country's Second National Communication to the UNFCCC, submitted in 2015, its Nationally-Determined Contributions to the UNFCCC submitted in 2016, and its National Adaptation Plan was completed in 2016. Kenya's climate change adaptation strategies focus on the preparation and strengthening of institutional frameworks for responsible environmental management, improved management of climate change effects and economic development targets. Furthermore, established institutions and mechanisms are in place to monitor the reduction in greenhouse gas emissions, to address vulnerabilities which will be exacerbated by climate change, and to strengthen the country's social and economic structures against vulnerability

RECOMMENDATIONS

RESEARCH GAPS

- Develop a better understanding of the occurrence and magnitude of climate change events and natural hazards

- Increase understanding of climate change related impacts on key vulnerabilities, related developmental

impacts, and the country's possible adaptation responses

- Strengthen environmental monitoring capabilities for strengthened and more effective environmental Management

. Enhance Kenya's adaptive capacity through continuing investment in weather stations and expanding the Kenya Meteorological Department's (KMD) national hydro-meteorological and seismological monitoring system for improved networking for the measurement of climate parameters

- Improve awareness and understanding of projected climate change impacts within key sectors and with policy makers, commission risk assessments, and expand early warning systems, specifically for public health

DATA AND INFORMATION GAPS

Improve observational data through by acquiring weather stations and hydro-meteorological, seismological instrumentation and mapping

- Improve technical capacity to analyze and interpret hydro-met data in support of impact assessments across sectors; specifically monitoring sea level rise

- Establish institutional capacity for providing timely early warning systems to farmers for improved decision making and understanding seasonal variability throughout Kenya's key agricultural zones. This should be coordinated with KMD's agrometeorological bulletins

- Increase understanding of water resource threats and groundwater risks to improve long term management and improve water use efficiency in agriculture and urban management

INSTITUTIONAL GAPS

Ensure integration of National Energy Strategy goals are developed within sectoral and regional plans

- Implementation of cross-sectoral climate-smart solutions at national and subnational levels

- Integrate climate change concerns into relevant policies and planning processes at the state and national levels
- Integrate seasonal forecasts and long-term climate change trends into healthcare policy and planning for improved and more prepared public health service in Kenya

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