COUNTY GOVERNMENT OF BUSIA
DEPARTMENT OF LANDS, HOUSING
& URBAN DEVELOPMENT
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MALABA MUNICIPALITY

CLIMATE RISK PROFILE

DRAFT

2026

Motto:

"Focus on development"

Vision:

*"*To be a Municipality where risks are managed to acceptable level*"*

Mission:

*"*Provision of a framework for effective management of risk to achieve enhanced service delivery*"*

Foreword

I acknowledge the Governor H.E Hon. Dr. Paul Nyongesa Otuma and his deputy H.E Arthur Odera, for the commitment to a better governance by putting in structures and mechanisms for the efficient delivery of services to the people in line with his agenda.

I am pleased to present this **Urban Climate Risk Profile**, a critical document that reflects our commitment to building a resilient, sustainable, and forward-looking urban community.

Malaba Municipality is experiencing rapid population growth, driven by urbanization, economic development, and its strategic role as a regional hub. However, this growth is increasingly challenged by the impacts of climate change, including extreme heat, erratic rainfall, and pluvial flooding. These hazards threaten our infrastructure, economy, and most importantly, the well-being of our residents—especially those in informal settlements and vulnerable groups.

This Climate Risk Profile is more than a technical assessment; it is a call to action. It provides a clear, evidence-based understanding of our current and future climate risks, identifies the systems and populations most at risk, and outlines practical adaptation measures that can be integrated into our planning and development processes.

The preparation of this document has been a collaborative effort, involving stakeholders from across government, civil society, the private sector, and local communities. Their insights have enriched this profile and ensured it reflects the lived realities of our municipality.

I urge all departments, development partners, and community leaders to use this document as a guide for decision-making. By mainstreaming climate resilience into our policies, investments and daily operations, we can safeguard Malaba's future and ensure that our growth is both inclusive and sustainable.

Together, let us build a Malaba that is not only thriving and cosmopolitan but also resilient to the challenges of a changing climate.

Municipality Manager

Malaba

January 2026

Executive Summary

This **Urban Climate Risk Profile for Malaba Municipality** presents a comprehensive assessment of current and future climate risks to guide resilient urban planning, infrastructure development, and community preparedness. The profile was developed through a participatory process involving county and municipal departments, technical experts, community representatives, and other key stakeholders, ensuring that local knowledge and priorities are integrated into the findings and recommendations.

Objective of the Rapid Climate Risk Assessment

The primary objective of this assessment is to systematically identify, analyze, and prioritize the climate hazards facing Malaba Municipality, evaluate the exposure and vulnerability of its people, assets, and systems, and translate this understanding into actionable strategies for climate adaptation and resilience. Specifically, it aims to:

- Inform the integration of climate risk into the County Integrated Development Plan (CIDP), urban spatial plans, and sectoral policies.
- Guide investment in climate-resilient infrastructure and services.
- Enhance community awareness and preparedness for climate-related events.
- Support evidence-based decision-making for long-term urban sustainability.

Key Climate Hazards Identified

Based on historical data, climate projections, and local experience, four primary climate hazards were identified as most significant for Malaba Municipality:

1. **Pluvial (Surface) Flooding** – Increased frequency and intensity of flash floods due to heavy, short-duration rainfall events.
2. **Changes in Precipitation Patterns** – Increased variability in rainfall timing, duration, and intensity, disrupting agricultural cycles and water availability.
3. **Extreme Heat** – Rising frequency and duration of heatwaves, exacerbating health risks and straining energy and water systems.
4. **Average Surface Temperature Increase** – A steady rise in baseline temperatures, amplifying other hazards and stressing ecosystems and livelihoods.

Table 1. Summary of pluvial flooding for Malaba Municipality

Category	Risk level				
	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP58.5
Infrastructure & Services					
Storm water Drainage	Low	Low	Low	Low	Low
Water &Wastewater Management	Low	Low	Low	Low	Low
Solid waste Management	Low	Low	Low	Low	Low
Transportation and Mobility	Low	Low	Low	Low	Low
Energy	Low	Low	Low	Low	Low
Economic infrastructure	Low	Low	Low	Low	Low
Emergency Services	Low	Low	Low	Low	Low
Social infrastructure	Low	Low	Low	Low	Low
Populations					
Urban Residents	Low	Low	Low	Low	Low

Category	Risk Level				
	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Informal Settlement Residents	Low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	Low	Low	Low	Low	Low
Natural Assets					
Urban Green Infrastructure	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	Low	Low	Low	Low	Low

Table 2. Summary of changes in precipitation patterns for Malaba Municipality

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

Table 3. Summary of extreme heat for Malaba Municipality

Category	Risk Level				
	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Infrastructure & Services					
Storm water Drainage	Low	Low	Low	Low	Low
Water & Wastewater Management	Low	Low	Low	Low	Low
Solid Waste Management	Low	Low	Low	Low	Low

Category	Risk Level				
	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Transport and Mobility	Low	Low	Low	Low	Low
Energy	Low	Low	Low	Low	Low
Economic Infrastructure	Low	Low	Low	Low	Low
Social Infrastructure	Low	Low	Low	Low	Low
Emergency Services	Low	Low	Low	Low	Low
Populations					
Urban Residents	Low	Low	Low	Low	Low
Informal Settlement Residents	Low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	Low	Low	Low	Low	Low
Natural Assets					
Urban Green Infrastructure	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	Low	Low	Low	Low	Low

Table 4. Summary of average surface temperature increase for Malaba Municipality

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

Key Takeaways & Priority Actions for Risk Mitigation

1. **Protect Vulnerable Populations First:**
   Informal settlement residents and marginalized groups face disproportionately high risks from flooding and extreme heat. **Immediate actions** should include community-led drainage cleaning, heat-health action plans, secure water access, and participatory upgrading of high-risk areas.
2. **Climate-Proof Critical Infrastructure:**
   While current risk to infrastructure is low, **future-proofing is essential**. Priority investments include:

- **Upgrading drainage systems** in stormy water zones (e.g., Malaba central Ward).
- Integrating **Water Sensitive Urban Design (WSUD)** principles, such as permeable pavements and bioswales, into all new road and construction projects.
- **Strengthening the energy grid** to handle increased cooling demand and heat-induced outages.

3. **Invest in Nature-Based Solutions (NBS):**
   Enhance urban resilience through nature. Protect and restore River Malakisi and Komiriai riparian zones, expand urban tree canopy for cooling, develop constructed wetlands for storm water management, and promote urban agriculture. These solutions provide cost-effective, multi- benefit adaptation.
4. **Strengthen Governance and Planning Integration:**
   Mainstream this risk profile into all planning processes. Update the CIDP, spatial plans, and sectoral strategies (water, health, agriculture) with mandatory climate resilience criteria. Formalize stakeholder engagement forums for continuous monitoring and adaptation.
5. **Build Long-Term Adaptive Capacity:**
   Prepare for uncertain futures. Develop robust early warning systems for floods and heatwaves. Promote climate-smart agriculture in peri-urban zones. Secure dedicated funding for climate adaptation and build technical capacity within municipal departments.

Conclusion:

Malaba Municipality stands at a critical juncture. The choices made today in planning, investment, and community engagement will determine its resilience tomorrow. This profile provides the roadmap. By acting decisively on these priorities—centering equity, leveraging nature, and fostering integrated governance—Malaba can navigate climate risks and secure a sustainable, prosperous future for all its residents.

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List of Acronyms

RCRA	Rapid Climate Risk Assessment
BGI	Blue-Green Infrastructure
BETA	Bottom-Up Economic Transformation Agenda
CAIP	County Aggregation and Industrial Park
CBA	Community-Based Adaptation
CBO	Community-Based Organization
CECM	County Executive Committee Member
CIDP	County Integrated Development Plan
CSO	Civil Society Organization
EAC	East African Community
EAP	Emergency Action Plan
EbA	Ecosystem-based Adaptation
EPR	Extended Producer Responsibility
FGD	Focus Group Discussion
GCF	Green Climate Fund
GBV	Gender-Based Violence
GIS	Geographic Information System
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
IUWM	Integrated Urban Water Management
KII	Key Informant Interview
NBS	Nature-Based Solutions
NCPB	National Cereals and Produce Board
NEMA	National Environment Management Authority
PWD	People With Disabilities
SACCO	Savings and Credit Cooperative Organization
SME	Small and Medium Enterprise
SSP	Shared Socioeconomic Pathway
SUMP	Sustainable Urban Mobility Plan
TVET	Technical and Vocational Education and Training
UCRP	Urban Climate Risk Profile
UGI	Urban Green Infrastructure
UNDP	United Nations Development Programme

WSUD	Water Sensitive Urban Design

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1. Context

1.1. Objective

This Urban Climate Risk Profile aims to assess current and future climate risks and guide decision making across local policies, urban planning and infrastructure development. This profile aims to support the development of resilient policies, integrate climate resilience into urban and land use planning, establish building standards and promote investment in climate resilient infrastructure. Overall, it seeks to strengthen Malaba's capacity to manage climate impacts and enhance community resilience.

1.2. Urban Context

According the 2019 National Census: The core Municipality population stands at 110,528 Male (54,725), Female (55,803).

Table 5: Malaba Municipality core population

Ward	Male	Female	Total	Percentage of Municipality	Population Density (per km²)
Amukura West	13,291	14,185	27,476	24.9%	3,049
Malaba North	8,238	7,420	15,658	14.2%	2,000
Malaba South	14,645	16,033	30,678	27.8%	1,116
Malaba central	10,048	12,762	22,810	20.6%	
Total	**46,222**	**50,400**	**110,528**	**100.0%**	**1,917**

Table 6: Demographic indicators and projections

Indicator	2019 Baseline	2023 Estimate	2027 Projection	Implications
Total Population	110,528	125,400	142,200	Increased service demand
Annual Growth Rate	3.2%	3.0%	2.8%	Infrastructure pressure
Youth (15-35 years)	45,612 (41%)	52,000 (41%)	58,500 (41%)	Employment needs
Children (0-14 years)	38,285 (35%)	42,500 (34%)	46,300 (33%)	Education requirements
Working Age (15-64)	65,835 (60%)	75,200 (60%)	85,300 (60%)	Economic opportunity
Elderly (65+ years)	6,408 (6%)	7,700 (6%)	10,600 (7%)	Healthcare needs
Dependency Ratio	67.9%	66.8%	66.7%	Economic support needs

The municipality has a mixed urban economy, functioning as a hub for markets, small-scale industry, services, and transport. A significant peri-urban smallholder agricultural sector also exists. Agriculture is a key local livelihood, with predominant production of maize, beans, and tobacco. This economic activity is, however, sensitive to climate variability and land degradatio

Malaba Municipality faces increasing environmental and social pressures from population growth, urban expansion, agricultural intensification, and changing climatic conditions. These pressures manifest as soil degradation, erratic rainfall, stormy water, reduced water reliability, waste management challenges, and biodiversity loss.

Planned developments and investments in Malaba Municipality are driving a significant shift from agricultural and low-density land use toward high-density commercial, residential, and industrial use.

1.2.1. Geographic area

Malaba Municipality is located within Busia County, Teso North Sub-county, along the Mombasa-

Malaba Road at the Kenya-Uganda Border. The Municipality plays host to cross border trade, and is about 450Km West of Nairobi, 154Km Northwest of Kisumu and 220Km Northeast of Kampala. It borders Uganda on the West, Teso South Sub-County to the South.

The coordinates of Malaba, Kenya are: 00°38'11.99"N, 34°15'34.20"E (Latitude: 0.635278;

Longitude34.275278). Malaba, Kenya sits at an average elevation of 1,180 metres (3,871 ft), above sea level.

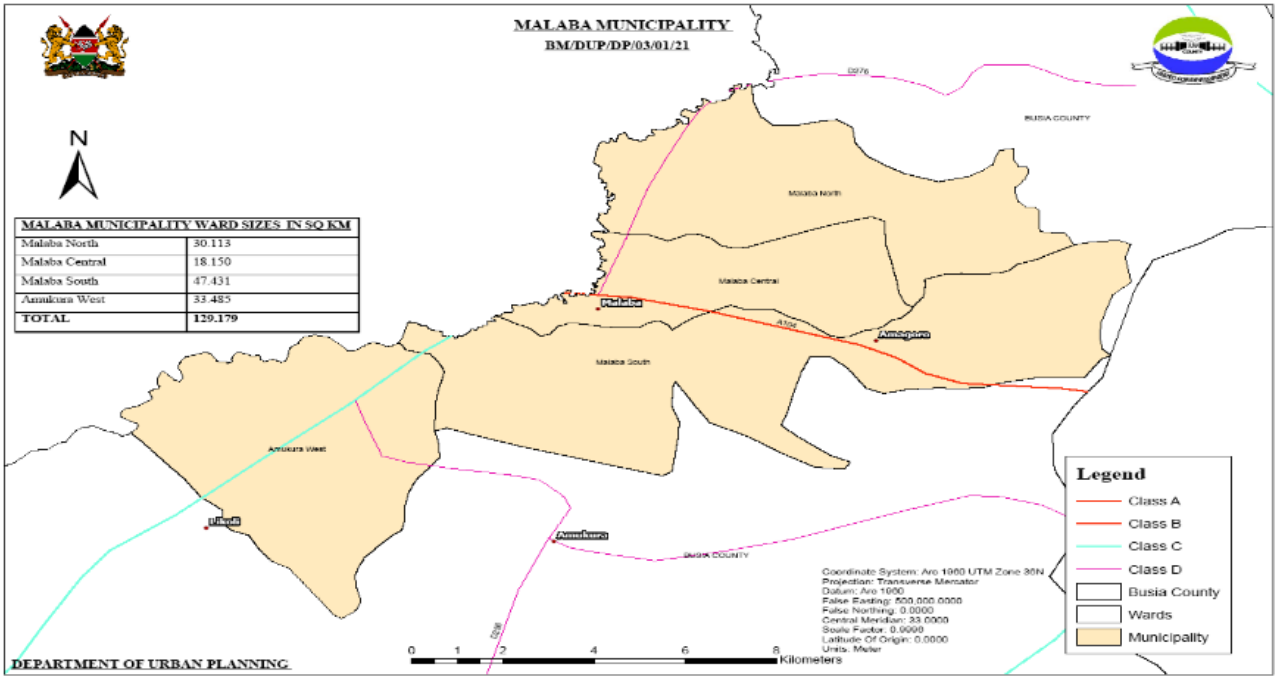


Figure 1: Map locating Malaba Municipality

1.2.2. Governance Structure

Level	Party	Role in Urban Climate Risk Profile / IDP
County Executive / Political Leadership	• Governor's Office (County Government of Busia) • County Executive Committee Member (CECM) for Lands, Urban & Physical Planning Busia County)	Sets strategic direction, approves policies and major plans; ensures alignment with County Integrated Development Plan (CIDP) and Urban Development Policy.
Sectoral Department	Department of Lands, Housing, Urban & Physical Planning – Busia County (within the County Government)Busia County)	*Urban & physical planning*, land-use mapping, survey & GIS, housing and municipal planning. Critical for climate risk profile (through spatial data, land use) and IDP (through urban planning inputs).
Municipal Board / Municipality Unit	Malaba Municipality Board / Municipality managing the town (Busia County)	Operational for the urban area – implementing local plans, zoning, infrastructure, municipal services. They take the urban risk/IDP ideas into local action. They coordinate the development of the IDP (which ties the spatial/physical plan with budgets, sector programmes) and ensure resources are allocated. For the Urban Climate Risk Profile specifically: assessing hazard, vulnerability, exposure; feeding into the plan for resilience. Sometimes placed under environment, disaster management or planning.
Stakeholders & Public Participation	• Community forums, Ward level representatives • Civil society, private sector, research institutions	They ensure inputs are inclusive, especially for risk profiling (vulnerable groups, informal settlements) and the IDP. Participation is mandated.
Monitoring & Oversight	• County Assembly Committee on Lands, Urban & Physical Planning, Housing & Municipalities (Busia Assembly)	Reviews and monitors departmental work, approves legislation, ensures accountability.

1.2.3. Socio-economic Context

Malaba Municipality is a rapidly growing urban center with a projected population of 107,162 (41%). According to the 2019 Kenya Population and Housing Census, the municipality comprises about 19,500 households with an average household size of 5 persons. The demographic data indicates a slightly higher population of women than men.

The township which is the core urban has the highest population density of about 4,935 persons per square kilometer due to the available business opportunities whereas all Locations having more households practicing agricultural activities has a low density of 863 persons per square kilometer.

The current municipality consists of thirteen major locations namely keng'atuny, Kocholia, Kokare, Kamolo, Onyunyur, Osajai, Kamuriai, Okuleu, Aremit, Akoret, Amagoro, Kadetewai and Amoni locations. Kadetewai, Amagoro and Amoni locations are the core urban area whereas the others fall under rural part of the municipality. The Municipality is also divided into four electoral wards of Teso North Constituency. The wards include; Malaba South, Malaba Central, Malaba North, and Amukura west.

1.2.4. Economic Context

The municipality's economy is dominated by micro, small and medium-scale enterprises, complemented by financial institutions and a robust transport service industry that capitalizes on its strategic road network location. Infrastructure development is comprehensive, featuring both government health facilities including the Kocholia Sub County Hospital, health centres and dispensaries, as well as private healthcare providers such as Comfy Hospital, Apex Hospitals. Educational services are provided through both public and private institutions offering the Competency Based Curriculum, while security is maintained through the Malaba Police Station network with various posts and patrol bases. Financial services are readily available through banks, micro-finance institutions, and mobile money transfer services, creating a well- rounded economic and social infrastructure that supports the municipality's role as a regional administrative and commercial Centres.

Agriculture dominates (sugar-cane, maize, dairy, vegetables) within the municipality rural areas. Within the municipality's urban area, processing, trade, services and small manufacturing (noted in municipal plan) contribute

With urbanization, services, trade, industrial processing expected to grow; increased demand for housing, utilities, municipal services; job shift from primary to secondary/tertiary sectors. Investments in infrastructure and urban services may catalyse new economic nodes.

1.2.5. Land-use Context

Malaba Municipality, the second Municipality of Busia County, is a strategically important agricultural and commercial hub in Western Kenya. Its economy is fundamentally agro- based, with significant cross-border trade linkages to Uganda. Current growth is driven by public investment, SME trade, and educational services, but is constrained by infrastructure gaps and low industrialization. The projection is for moderate, steady growth, heavily influenced by county and national government development plans, with potential for acceleration if key transport and value-addition projects are realized.

Current Economic Context (2023 - 2024)

Key Drivers & Strengths

- **Agricultural Trade & Processing:** The municipality is the primary market for the county's vast agricultural output (maize, dairy, poultry, bananas). It hosts milling operations, milk coolers, and a vibrant cereal trade. The **Malaba National Cereals and Produce Board (NCPB) depot** is a critical node.

- **Commercial and Retail Hub:** Serves as the wholesale and retail center for the entire Teso North and parts of neighboring counties and Uganda. **Malaba town and Amagoro** are major market centers.
- **Public Sector Employment:** As the county headquarters, it hosts the county government offices, providing significant formal employment and stimulating demand for services.
- **Cross-Border Trade: Malaba border points is** a key transit and supply town for goods moving from Kenya to Uganda.

Major Constraints & Challenges

- **Over-reliance on Agriculture:** The economy is highly vulnerable to climatic shocks (extreme temperatures, floods), commodity price fluctuations, and challenges in the farming sector.
- **Infrastructure Deficits:** Inadequate and poorly maintained urban roads, traffic congestion, unreliable water supply, and intermittent electricity in industrial areas hinder business growth.
- **Limited Value Addition:** Most agricultural exports are raw or semi-processed (e.g., maize, milk), leading to lost potential for jobs and higher income. The closure or underperformance of agro-processing plants is a recurrent issue.
- **High Urban Unemployment:** A large youth population faces a mismatch between skills and market needs, leading to high informal sector engagement and underemployment.
- **Regulatory Hurdles:** Businesses often cite multiple county licensing fees and bureaucratic delays as impediments to growth.

Projected Economic Context (2025 - 2030)

The projection is framed by the **Busia County Integrated Development Plan (CIDP) 2023-2027**, the **Kenya Vision 2030** blueprint, and national initiatives like the **Bottom-Up Economic Transformation Agenda (BETA)**.

Positive Projections & Opportunities

1. **Infrastructure-Led Growth:**
    - **Railway:** The revival of the **Metre Gauge Railway (MGR)** for cargo could position Malaba as a logistics hub for western Kenya.
2. **Agricultural Transformation:**
    - Shift from subsistence to **market-oriented, climate-smart agriculture**. Projected growth in high-value crops like bananas (already a success story), horticulture, and soybean cultivation.
    - Enhanced dairy and poultry farming through county-supported cooperatives and extension services.

3. **Services and Digital Economy Expansion:**
    - Growth in **financial services** (mobile money, agency banking, SACCOs) and **business process outsourcing** (BPO) leveraging the young, educated population.
    - Expansion of the **healthcare and hospitality sector** to serve a growing urban middle class and regional clientele.
4. **Cross-Border Trade Enhancement:** Formalization and digitization of border processes under the **East African Community (EAC)** protocols could increase the volume and efficiency of trade passing through Malaba.

Risks and Challenges to Projections

1. **Implementation Capacity:** The realization of projects like the Amoni market is contingent on effective county governance, absorption of development funds, and attracting private-public partnerships (PPPs).
2. **Fiscal Constraints:** Both national and county governments face budget constraints, which could delay large capital projects.
3. **Political Dynamics:** Changes in county or national leadership could alter priorities and funding allocations.
4. **National Economic Headwinds:** High national public debt, inflation, and exchange rate volatility affect the cost of projects and purchasing power of consumers.
5. **Climate Change:** Increasing frequency of extreme weather events remains a direct threat to the agricultural base.

Sectoral Outlook

- **Real Estate & Construction: Projected to be the fastest-growing sector.** Driven by urban migration, demand for commercial spaces, and improved infrastructure. Satellite centres like **Kocholya** and **Amagoro** will see significant expansion.
- **Manufacturing:** Growth is **highly contingent** on the successful establishment of the CAIP. Without it, growth will remain minimal, limited to small-scale agro-processing and workshops.
- **Trade & Commerce: Steady growth projected**, linked to population increase and agricultural productivity. Modern retail chains may begin to establish a presence.
- **Transport & Logistics:** Growth potential is **high**, directly tied to road and railway upgrades and cross-border trade.
- **Agriculture: Moderate growth projected**, moving towards diversification and value addition, but remains susceptible to external shocks.

Malaba Municipality stands at a potential inflection point. Its baseline projection is for steady, incremental growth as a regional market town. However, there exists a high-upside scenario where it transforms into a regional agro-industrial and logistics hub. This transformation is critically dependent on the execution of flagship infrastructure projects, particularly the County Aggregation and Industrial Park, and sustained improvements in the business environment. The next 5-7 years will be decisive in determining which trajectory the municipality's economy follows.

1.3. Key Stakeholders & Inclusiveness

How stakeholders are engaged in the preparation of the urban climate risk profile

1. **Stakeholder identification & mapping**

- The project team (led by the municipality) compiles a comprehensive list of stakeholders across categories: government, civil society, private sector, etc.
- They analyze stakeholders' **interest**, **influence**, and **capacity** (this is well documented in Kenya's climate stakeholder mapping literature)
- They then prioritize which stakeholders must be involved at which levels (e.g., high-influence/high-interest vs. low-influence/low-interest).

2. Initial consultations and scoping

- A launch meeting/workshop brings key stakeholders together (e.g., county department heads, municipal planning, environment unit, community reps).
- Scoping involves sharing the purpose of the UCRP, preliminary hazard/vulnerability ideas, and asking stakeholders their views on key risks.
- Methods: focus group discussions (FGDs), key informant interviews (KIIs) with department heads, informal stakeholder gatherings.

3. Data gathering & participatory input

- Technical teams collect hazard, exposure, vulnerability data (climate, socio-economic, and infrastructure).
- Stakeholders are asked to contribute local knowledge: for example, community groups provide insights on flood history, informal settlement vulnerabilities.
- Specific methods: community mapping exercises, town hall meetings, ward-level workshops.
- Research shows that meaningful stakeholder engagement improves performance of climate adaptability projects in Kenya.
- Technical institutions may hold training workshops to help community stakeholders understand climate risk concepts.
- Sectoral departments provide input on service infrastructure vulnerability (water, sanitation, and housing).

4. Risk analysis & draft profiling

- The collected data is analyzed (hazard x exposure x vulnerability) and a draft risk profile is prepared.
- Stakeholders are invited to review the draft: e.g., municipal engineers, community leaders, private sector (insurance, real estate) review what risks have been identified, check accuracy.
- Feedback loops: workshops where the draft is presented; comment sheets are circulated.
- This ensures buy-in and helps surface omitted risks (for example, risks faced by marginalized groups).
- In Kenya's mapping of stakeholders for climate change, research institutions, CSOs and private sector were flagged as key for evidence generation and review.

5. Prioritization of risks & identification of adaptation/resilience measures

- Stakeholders help prioritize which risks are highest (based on severity, frequency, cost, exposure).
- They also suggest adaptation/resilience measures and where they should be targeted (which wards, which infrastructure).
- Input is again from cross-stakeholder groups: municipal planning, CBOs, developers, utilities.

- Here the private sector might identify investment risks; community groups might highlight informal settlement risks.
- Workshops, multi-stakeholder forums, consultation surveys are used.

6. Finalization and endorsement of the UCRP

- The final profile is compiled, summarizing key hazards, vulnerable zones/populations, and recommended actions.
- It is presented to formal governance bodies: municipal council/board, county executive committee, possibly county assembly committee.
- Stakeholders are formally invited for a validation workshop.
- Once endorsed, it is published and/or integrated into plans (e.g., municipal development plan, IDP).

7. Mainstreaming & link to plans (including the Integrated Development Plan)

- The UCRP is fed into the planning process (IDP, spatial plan, sector plans). Stakeholders remain engaged to ensure mainstreaming: planning department, environment unit, infrastructure, service departments.
- Civil society and community groups may be engaged in monitoring early implementation or ensuring that adaptation measures reach vulnerable communities.
- Private sector may engage around financing/insurance of adaptation measures.
- Media and communication stakeholders help disseminate the risk profile findings to the public and raise awareness.

8. Monitoring, review and revision

- Stakeholders continue to play roles in periodic review of the risk profile (e.g., every 5 years or aligned with plan cycles).
- Community feedback mechanisms allow local people to report new risks or changing vulnerabilities.
- Researchers and technical institutes may undertake updated hazard modeling and feed back into the UCRP.
- Development partners/funders may monitor how adaptation actions derived from UCRP are being carried out.

STAKEHOLDERS AND THEIR ROLES INCLUDE:

1. Government / Public sector

- National-level agencies (e.g., National Environment Management Authority (NEMA), Kenya Meteorological Department, Ministry of Environment and Forestry)
- County-level government departments (for Busia: e.g., County Department of Lands, Housing, Urban & Physical Planning; County Environment & Climate Change Unit; County Planning & Economic Development)
- Municipal / town authorities (Malaba Municipality Board, municipal planning unit, infrastructure & services branch)
- Sectoral departments (e.g., Water & Sanitation, Agriculture, Health, Transport, Housing & Urban Development)
- Legislative oversight bodies (e.g., County Assembly Committee on Lands, Urban Planning & Housing)
- Disaster risk management agencies (if separate)

2. Research & technical institutions

- Universities and research institutes (environmental sciences, climate change, urban studies)
- Technical consultants and firms (GIS, spatial planning, hazard assessment)
- Meteorological and climate data agencies / mapping bodies
- NGOs with technical capacity (especially for climate risk and resilience assessments)

3. Civil society & community groups

- Local community-based organizations (CBOs), grassroots groups in urban wards / informal settlements
- Vulnerable/marginalized groups and their associations (people with disabilities, women's groups, youth groups, ethnic minorities)
- Faith-based organizations (important in your context, Hadassah)
- Informal settlement associations, slum upgrading groups
- Community leaders (ward reps, village elders, neighborhood committees)

4. Private sector

- Businesses (especially those in sectors vulnerable to climate risk: e.g., construction, real-estate, utilities, insurance)
- Developers and infrastructure firms
- Utility service providers (water, electricity, sanitation)
- Insurance companies (in climate risk profiling these are increasingly important)

5. International/development partners & funders

- Bilateral/multilateral development agencies (e.g., Green Climate Fund (GCF), United Nations Development Programme (UNDP))
- Climate adaptation programmes / donors
- World Bank
- Technical assistance providers

6. Media & knowledge/communication actors

- Local media (radio, newspapers, online)
- Communication & outreach agencies
- Knowledge-sharing platforms

7. Infrastructure & service providers

- Utilities (water, sanitation, electricity)
- Transport authorities
- Housing authorities
- Waste-management agencies

8. Other stakeholders

- Financial institutions (banks, microfinance)
- Insurance & risk assessment groups
- Informal economy actors (markets, traders)
- Indigenous/traditional authorities or institutions (if relevant)

High

High Influence – Low Interest • County Treasury / Finance departments • Private sector – Large businesses / utilities (unless directly impacted) • Transport authorities (may prioritize mobility over resilience) • National ministries not directly linked to environment (e.g., Interior, Energy) • Financial institutions (banks, microfinance) – unless climate finance is involved	**High Influence – High Interest** • County Executive Committee Member (CECM) – Lands, Housing, Urban & Physical Planning • Department of Lands, Housing, Urban & Physical Planning (County) • Municipality Board / Municipal Planning Unit (malaba Municipality) • County Environment & Climate change department and other sectoral departments like water, tourism, transport, health, urbanization.
Low Influence – Low Interest • General public (unless organized) • Some private sector SMEs not in vulnerable sectors • Certain media outlets without focus on environmental issues • Indigenous/traditional authorities – unless specifically affected or consulted • Knowledge-sharing platforms without active local engagement	**Low Influence – High Interest** • Community Based Organisations (CBOs), Ward-level groups, Informal Settlement Associations • Faith-based organisations & women/youth groups • Research Institutions / Technical Consultants / Universities • Vulnerable / Marginalised Groups (People with disabilities, minorities, women, children)

Low High

Figure 2: Stakeholder mapping for Malaba Municipality

2. Hazard Assessment

Malaba Municipality has in the recent years experienced climate induced hazards, like the recent flashfloods that were experienced in September of 2025. These events risk loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. The purpose of this chapter is to properly identify hazards within our municipality.

2.1. Key Climate Hazards

Table 7: Hazard screening for Bungoma Municipality

Hazard	Hazard Likely (Y/N)	Significant Impact (Y/N)	High Priority (Y/N)	Key Hazard (Y/N)
Heat Stress				
Average surface temperature increase	Y	Y	Y	Y
Average ocean temperature increase	N	N	N	N
Extreme heat	Y	Y	Y	Y
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
Pluvial (surface level) flooding, including flash flooding and urban flooding	Y	Y	Y	Y
Fluvial (river) flooding	N	N	N	N
Sea level rise	N	N	N	N
Coastal flooding, including storm surges	N	N	N	N
Waterlogging	N	N	N	N
Water Stress				
Drought (meteorological, hydrological)	N	N	N	N
Groundwater salinization	N	N	N	N
Saline intrusion	N	N	N	N
Wildfire				
Wildfires & bushfires	N	N	N	N
Storms				
Extreme wind	N	N	N	N
Tropical cyclones	N	N	N	N
Sand and dust storms	Y	Y	Y	N
Hailstorms	Y	Y	Y	N
Mass Movement				
Landslides	N	N	N	N
Coastal erosion	N	N	N	N
Gully erosion	N	N	N	N
Marine Conditions				
Ocean acidification	N	N	N	N
Geophysical*				
Subsidence	N	N	N	N
Earthquakes	N	N	N	N

Hazard	Hazard Likely (Y/N)	Significant Impact (Y/N)	High Priority (Y/N)	Key Hazard (Y/N)
Volcanos	N	N	N	N

** These hazards, if present, can be highly impactful and are therefore included in the screening step, as they may significantly influence the urban planning informed by this urban climate risk profile.*

2.2. Climate Indicators and Hazard Thresholds

Table 8: Climate Indicators and hazard thresholds selected for the assessment

Key Hazard	Climate indicator	Data source	Threshold		
			Low	Medium	High
Average surface temperature increase	Maximum of daily max-temperature	World bank climate change knowledge portal	27.39℃		
Changes in precipitation patterns	Precipitation percent change	World bank climate change knowledge portal	90%		
Pluvial (surface level) flooding, including flash flooding and urban flooding	#of days with precipitation >50mm	World bank climate change knowledge portal	1 day		
Extreme Heat	# days with heat index > 35°C (Mean)	World bank climate change knowledge portal	0 days		

2.3. Current Hazard Levels and Climate Projections

For decades, Malaba Municipality has experienced a slow but perceptible shift in its core climate patterns—the very rhythms of heat and rain that govern its agrarian life. This is not a story of sudden disaster, but of a gradual tilting of the climatic baseline, making the familiar weather of the past increasingly unreliable.

The Creeping Change: Chronic Hazards

Average Surface Temperature Increase: Historical meteorological data and community observations converge on a clear trend: nights and dry seasons are growing warmer. The

Average annual temperature has been on a steady, incremental climb over the past 30-40 years. This isn't just about hotter afternoons; it's a rise in the baseline heat that reduces nighttime recovery for crops, increases evaporation from soils and water reservoirs, and subtly raises energy demand.

Changes in Precipitation Patterns: The story of rainfall is one of disruption rather than simple decrease. The long-rains (March-May) and short-rains (August-October) seasons, once predictable pillars for planting calendars, have become more erratic. The trends show:

Increased Intensity: When it rains, it often pours more intensely within shorter periods.

Temporal Shifts: The onset and cessation of rains are less reliable, with more false starts and earlier or later withdrawals.

Spatial Variability: Rainfall distribution has become patchier, with some areas in the municipality receiving near-normal totals while adjacent zones face significant deficits.

From Chronic Shift to Acute Crisis: Implications for Hazards

These gradual changes in background climate are actively loading the dice, increasing the frequency and severity of acute, damaging events:

Implication for Extreme Heat: The rising average temperature directly increases the probability, duration, and intensity of heatwaves. What was once considered a rare exceptionally hot day is becoming more common? Heat stress periods now coincide more frequently with critical crop flowering stages and pose growing health risks to the vulnerable, including outdoor market traders and laborers. The chronic warming ensures that acute heat events start from a higher baseline, making them more severe.

Implication for Pluvial Flooding: The altered precipitation patterns are the primary driver of increased pluvial (surface) flooding. The municipality's aging drainage infrastructure, designed for the gentler, more prolonged rains of the past, is now consistently overwhelmed by high-intensity downpours. These sudden deluges lead to rapid runoff, causing flash floods in low-lying and poorly drained areas of the town center and informal settlements like Ikapoloko. The flooding is acute and destructive, washing out urban roads, contaminating water sources, and disrupting market access, but its root cause is the chronic shift in how rain falls.

The Compound Reality

The true impact lies in the compound nature of these hazards. A period of extreme heat can desiccate soils and stunt crops, which is then followed by an intense pluvial flood that cannot infiltrate the hardened ground, resulting in greater runoff and erosion that washes away topsoil and seeds. This sequence devastates both urban resilience and the rural agricultural hinterland upon which the municipality's economy depends.

In summary, Malaba’s history shows a clear trajectory: a warming, less predictable climate is systematically amplifying local hazards. The chronic, creeping changes in temperature and rainfall patterns are not just background statistics; they are the active engines making extreme heat more punishing and pluvial floods more frequent and destructive, thereby threatening the municipality's economic stability, public health, and urban infrastructure.

Table 9: Current and future hazard levels for Malaba Municipality.

	Hazard Level

Hazard	Current (Baseline)	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Average surface temperature increase	Low	2.8℃	3.04℃	3.23℃	4.68℃
Changes in precipitation patterns	Low	17% Low	17% Low	20% Low	51% Medium
Pluvial (surface level) flooding, including flash flooding and urban flooding	Low	0 days Low	0 days Low	0 days Low	0 days Low
Extreme Heat	Low	-2days Low	-2 days Low	-2 days Low	-2 days Low

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

Table 10: Interpretation of hazard levels

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

2.4. Current and Future Hazard Impact Areas

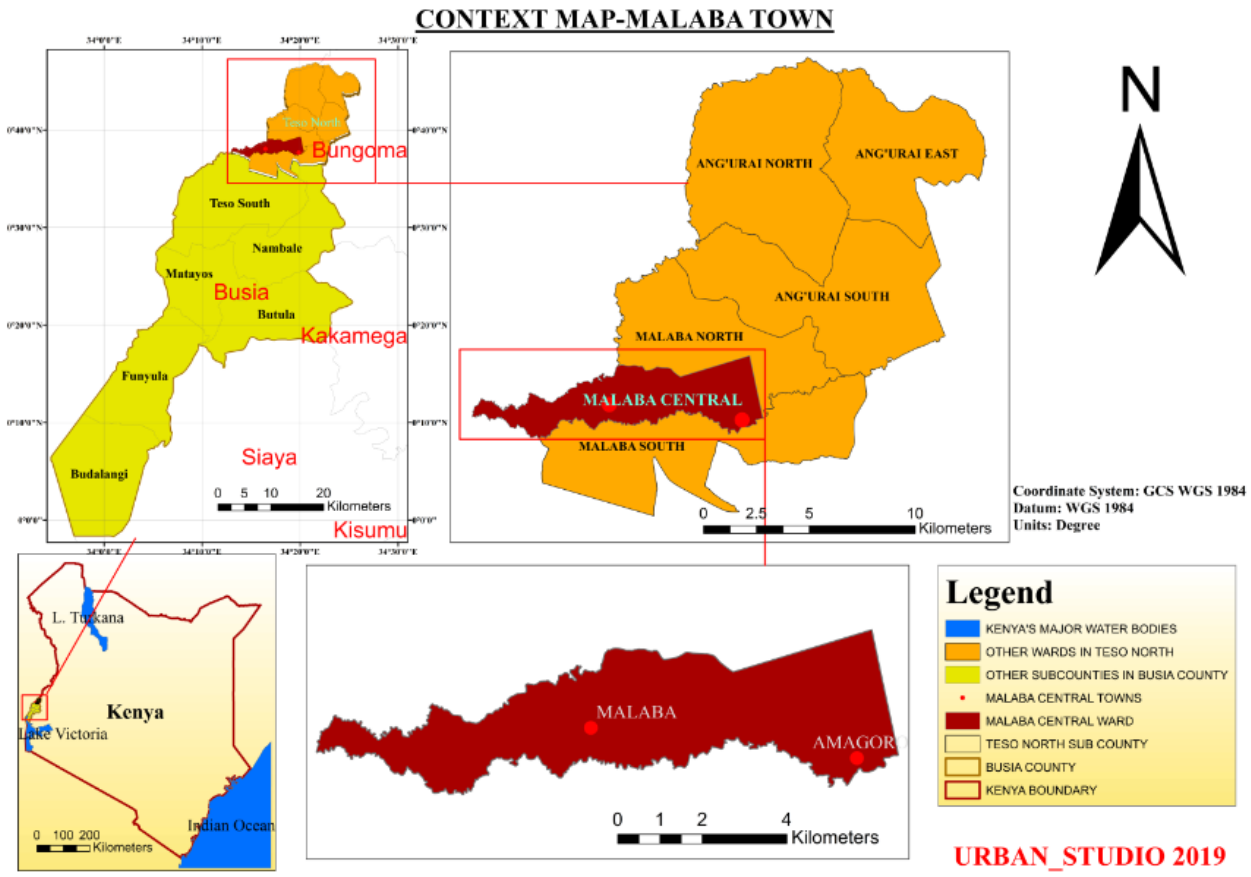
Roadside parking
Frequent fire incidents involving trucks, such as a recent explosion of a gas cylinder in a driver's cabin, occur along the main highway, creating hazards for traders and residents.

Road accidents
Ikapoloko, Koteko, Kajei, Iukolis, Amairo and Roadblock on the Malaba – Bungoma route

Floods
Heavy rainfall frequently leads to severe flooding, destroying homes and crops, particularly along the Malakisi River and other areas as:
Machakus, Akiriamas, Okouk, Parater, Okwata, Amoni and korisai

Storm water.
Malaba CBD is the most affected area on storm water

Sewage pollution zones
Certain areas, similar to issues in neighboring wards face health hazards due to sewage flowing into residential areas which may result to disease outbreak.


CONTEXT MAP-MALABA TOWN
Bungoma
Teso South
Nambale
Matayos
Busia
Butula
Kakamega
Funyula
Siaya
Budalangi
Kisumu
0 5 10 20 Kilometers
ANG'URAI NORTH
ANG'URAI EAST
ANG'URAI SOUTH
MALABA NORTH
MALABA CENTRAL
MALABA SOUTH
0 2.5 5 10 Kilometers
N
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
L. Turkana
Kenya
Lake Victoria
Indian Ocean
0 100 200 Kilometers
MALABA
AMAGORO
0 1 2 4 Kilometers
Legend
KENYA'S MAJOR WATER BODIES
OTHER WARDS IN TESO NORTH
OTHER SUBCOUNTIES IN BUSIA COUNTY
MALABA CENTRAL TOWNS
MALABA CENTRAL WARD
TESO NORTH SUB COUNTY
BUSIA COUNTY
KENYA BOUNDARY
URBAN_STUDIO 2019

3. Exposure & Vulnerability Assessment

This chapter presents a critical analysis of the Exposure and Vulnerability of Malaba Municipality's people, assets, and systems to key urban climate hazards. Moving beyond the identification of hazards in the previous chapter, this assessment delves into the *who* and *what* that are at risk, and the underlying conditions that determine the severity of potential impacts. It systematically maps the spatial distribution and concentration of exposed populations, critical infrastructure, economic activities, and sensitive ecosystems. Concurrently, it evaluates the multidimensional vulnerability—encompassing physical, social, economic, and institutional factors—that shape the municipality's capacity to anticipate, cope with, and recover from climate stressors. This integrated exposure and vulnerability profile is fundamental for prioritizing interventions and building targeted resilience in Malaba.

3.1. Urban Elements

Table 11: Urban Elements Inventory

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Infrastructure & Services				
Storm water Drainage	Storm water drainage conveyance network	Y	N	Storm water drainage network along tarmacked roads
	Storm water storage	N	N	N/A
Water & Wastewater Management	Pumping stations	N	N	N/A
	Groundwater abstraction	N	N	N/A
	Water treatment facilities	N	N	N/A
	Water supply networks	Y	N	BUWASCO
	Sewer networks	Y	N	BUWASCO
	Wastewater treatment facilities	Y	N	Located in Malakisi
Solid Waste Management	Transfer facilities	N	N	N/A
	Landfills and dump sites	Y	Y	Kajei dumpsite
	Recycling centers	N	N	N/A
	Collection fleet	Y	N	Public private partnership
Transport and Mobility	Road networks	Y	Y	All tarmacked and all weather roads within the municipality
	Bridges	Y	Y	
	Public transport networks (rail, bus, mini-bus, etc.)	Y	Y	All roads and rail networks
	Transportation terminals	Y	Y	malaba bus park
	Vehicle depots	N	N	N/A

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Non-motorized transport networks	Y	Y	Footpaths alongside tarmacked roads
	Freight and logistics hubs	N	N	N/A
Energy	Energy power plants	N	N	N/A
	Poles and power lines	Y	N	Most power lines are found along our roads
	Transformers and substations	Y	Y	At Malaba Bus park
	Streetlighting	Y	Y	Along Amagoro town road
Economic Infrastructure	Markets	Y	Y	Amoni market and Amagoro market still under construction
	Businesses and commercial hubs	Y	Y	Malaba CBD
Social Infrastructure	Government buildings and service centers	Y	Y	Buildings offering government services, e.g Malaba law court
	Education facilities	Y	Y	There are many primary and secondary schooled within The municipality.
	Healthcare facilities	Y	Y	There are many private owned health facilities and a major government hospital in Malaba municipality
	Public spaces	Y	Y	Malaba stadium
	Faith-based buildings	Y	Y	Malaba municipality has many churches, a few mosques and a temple
	Cultural and heritage assets	N	N	N/A
Emergency Services	Fire stations	N	N	N/A
	Police stations	Y	Y	Malaba Police Station
	Telecommunications networks	Y	Y	Mostly along the roads
	Early warning systems	N	N	N/A
	Disaster management centers and shelters	N	N	N/A
	Evacuation routes	N	N	N/A

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Populations				

Urban Residents	Population	Y	Y	As per 2019 census, Malaba municipality has a population of 102,246
	Households	Y	N	N/A
Informal Settlement Residents	Population living in informal settlements	Y	N	N/A
	Households lacking land tenure	Y	N	N/A
	Households / residents lacking access to basic services	Y	N	N/A
Vulnerable and Marginalized Groups	Low-income households	Y	N	N/A
	Women-headed households	Y	N	N/A
	Children and youth	Y	N	N/A
	Elderly persons	Y	N	N/A
	People with disabilities (PWD)	Y	N	N/A
	Homeless populations	Y	N	N/A
	Unemployed or precariously employed workers	Y	N	N/A
	Seasonal workers / migrant laborers	Y	N	N/A
	Nomadic groups in peri-urban areas	N	N	N/A
	Urban refugees and migrants	N	N	N/A
	Minority ethnic groups in urban areas	N	N	N/A
Natural Assets				
	Green corridors	Y	N	N/A
	Urban forests and forest reserves	Y	N	N/A
	Rivers	Y	Y	River Malakisi and Komiriai
	Riparian zones	Y	Y	Along Malakisi and Komiriai
	Lakes, ponds and reservoirs	Y	N	N/A
	Coastal ecosystems	N	N	N/A

Category	**Subcategory**	**Included in the RCRA (Y/N)**	**Available in GIS format (Y/N)**	**Description**
	Urban agriculture	Y	N	Many people who have farms around the township area practice agriculture
Peri-urban	Peri-urban agriculture	Y	N	N/A
	Agroforestry systems	N	N	N/A
	Forests and forest reserves	N	N	N/A

and Agricultural Systems	Protected areas and national parks	N	N	N/A
	Savannahs and rangelands	N	N	N/A

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

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

Table 12: Interpretation of exposure and vulnerability levels

Level	Exposure Level Interpretation	Vulnerability Level Interpretation
High	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 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	Few or no critical urban elements lie within the hazard footprint or area of impact.	The urban element is minimally vulnerable to the climate hazard due to limited sensitivity and/or a high degree of adaptive capacity.

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

Table 13: Impact Matrix

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

Record any data sources used to complete the table in Annex-N2.]

Table 14: Exposure, Vulnerability and impacts of pluvial flooding on urban elements.

Hazard: *Pluvial flooding*

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					
Storm water Drainage	• The municipality boasts of a robust stormwater drainage channel, guided by the natural drainage and leads most of the waters to river Malakisi • Some of the drainage channels have suffered infrastructure damage, for example near the county referral hospital • Sometimes during the rainy season, the channels appear to have inadequate capacity due to blockage and siltation • Some feeder roads in Malaba central Ward have no drainage or only on one side which overwhelms its capacity to hold water during rains and cause flashfloods.	Low	**Sensitivity:** • Most drainage channels within the municipality are constructed with good material. • Most of the drainage covers are missing, and a lot of dirt gets trapped and eventually causes blockages during rainy season an may lead to flash floods (systemic failure) **Adaptive Capacity:** • Routine maintenance • Targeted improvements • Water Sensitive Urban Design (WSUD) / Sponge Cities like permeable pavements	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Water & Wastewater Management	• Malaba municipality is served by BUWASCO which provides water and sewer services. Some dwellers are not connected to the grid because they have dug their own wells and sewers and toilets • The municipality boasts of a modern sewer line with a treatment facility. The only challenge is that it does serve just a small portion of the community as most dwellers have dug their own septic pits in Their homes.	Low	**Sensitivity:** • Like any other infrastructure, the water and wastewater management system can suffer damage during flashfloods, leading to unhygienic conditions like Contamination of drinking water sources. **Adaptive Capacity:** • Structural upgrades • Maintenance and cleaning • Connecting more households to the grid will improve service delivery	Low	Minor
Solid Waste Management	• The municipality hosts a dumpsite which receives solid waste from the whole county. This is done through a public – private partnership. Trucks deliver the waste every day. • The municipality does not have properly designated waste collection points. We have areas where the waste is dumped and collected from, for example, at Malaba CBD • The trucks are not modernized, exposing workers to health risks.	Low	**Sensitivity:** • Collection services can easily be disrupted during pluvial flooding leading to environmental contamination and increased management costs • The dumpsite is well fenced but soon it's capacity will be overstretched because it receives waste and there is not recycling **Adaptive Capacity:** • Integrated planning; Combining waste management with flood risk reduction • Community Engagement: Promoting better waste disposal practices. • Improved Infrastructure: Building resilient waste facilities and upgrading drainage.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Energy	• There is an electricity substation within the municipality NOT operational • Most municipal dwellers use electricity and are connected to the power grid.	Low	**Sensitivity:** • In case of flashfloods, there is risk to damage to transmission and distribution infrastructure, leading to power outages and service disruptions. **Adaptive Capacity:** • Predictive modeling • Emergency planning	Low	Minor
Economic Infrastructure	• Key components of our municipal economic infrastructure include; roads, railway, electricity lines,	Low	**Sensitivity:** • Reduced ability to cope with disruptions which may lead to systemic failure. •	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Nature-Based Solutions (NbS): Implementing green roofs, bioswales, and retention basins to reduce runoff and alleviate pressure on gray infrastructure. • Structural Improvements: Increasing pipe network capacity, deep tunnel construction, and improving drainage to manage peak flows.		
Social Infrastructure	• Destruction of critical facilities • Negative impact to housing and settlements • Vulnerable populations are mostly affected • Our social infrastructure in the municipality includes; many hospitals, schools, housing, a prison. Previously some of these social facilities have had flooding problems and it affects the service delivery. For example, Malaba Primary School where flashfloods uprooted trees and disturbed learning for a while.	Low	**Sensitivity:** • The town which hosts the municipality is well planned • There is risk of structural damage and operation disruption in some areas that are prone to flashfloods **Adaptive Capacity:** • Social Learning: Institutional learning and the ability of communities to learn from past flood experiences and adapt future strategies. • Community-Based Adaptation (CBA): Empowering local residents to act as primary agents in managing flood risk through participatory, inclusive mechanisms •	Low	Minor
Emergency Services	• Malaba municipality has a range of emergency services that include hospital ambulances, police services, social	Low	**Sensitivity:** • Possibility of being overwhelmed in case of an emergency	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	services offered by Red Cross.		**Adaptive Capacity:** • Community Empowerment: Enhancing public awareness, social capital, and local knowledge (e.g., recognizing flood signs) to enable better individual and collective action. • Infrastructure & Planning: Investing in drainage, pumping stations, public shelters, and safe evacuation routes, alongside land-use planning to reduce vulnerability. • Institutional Collaboration: Fostering information sharing and coordinated efforts between diverse agencies (spatial planning, crisis management) and building trust with the public.		
Populations					
Urban Residents	• Municipal population as of 2019 census stands at 102, 246 41% of this population is found within the urban areas	Low	**Sensitivity:** • Areas that are low lying and prone to stormy water are mostly in Malaba central Ward. Some of the urban residents live in informal settlements that are likely to be severely impacted by the flashfloods	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Ecosystem-based Adaptation (EbA): Restoring natural systems (like wetlands) to buffer floods. • Coping Mechanisms (Short-term): Immediate actions like sandbagging, moving valuables. • Incremental Adaptation (Medium-term): Adjustments like raising property or improving home defenses		
Informal Settlement Residents	• Approximately **102,246 people** living in informal settlements within Malaba Municipality	Low	**Sensitivity:** • Insecure Tenure: Lack of legal land rights disincentivizes long-term investment in structural improvements. • Financial Limitations: Poverty restricts the ability to adopt more effective or permanent adaptation measures. **Adaptive Capacity:** • Integrated Policy: Moving beyond just building stronger houses to incorporating social, economic, and institutional dimensions into urban planning. • Community-Led Reblocking: Spatial rearrangement to improve drainage and access.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Vulnerable and Marginalized Groups	• This group includes; women (GBV), monetarily poor, PWDs, the elderly, PLWHIV among others	Low	**Sensitivity:** • Increased Exposure: Often live in flood-prone areas (e.g., informal settlements, low-lying zones). • Higher Sensitivity: Health, food, and water systems are more vulnerable to disruption. • Slower Recovery: Longer recovery times and greater reliance on informal networks. **Adaptive Capacity:** • Integrate Community Knowledge: Empower local leaders and use citizen-led approaches for tailored solutions. • Improve Governance: Ensure inclusive planning, adequate investment, and equitable resource distribution.	Medium	Minor
Natural Assets					
Urban Green Infrastructure	• Along transport corridors for example Malaba CBD.	Low	**Sensitivity:** • It is a very small space and therefore , its impact is small in the municipality **Adaptive Capacity:** • Increase the green spaces in the municipality • Strategic spatial planning	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Urban Blue Infrastructure	• Including rivers Malakisi and Komiriai Rivers.	Low	**Sensitivity:** • The river and wetlands carry capacity to hold flashflood water • Possibility of contamination due to poor sanitation within the municipality • **Adaptive Capacity:** • Regular maintenance for the engineered blue infrastructure • Conservation of natural areas like rivers and springs	Low	Minor
Peri-urban and Agricultural Systems	• Characterized by subsistence farmers, dairy farmers, horticulture(vegetables), in	Low	**Sensitivity:** • Crop loss and farmland destruction , livestock losses in case of flashfloods	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	areas like malaba central, malaba south, malaba north and Amukura west • There is significant uncontrolled sprawl of urban areas into prime agricultural land. The municipality is experiencing land fragmentation, leading to smaller, less economical landholdings.		**Adaptive Capacity:** • Blue-Green Infrastructure (BGI): Strategic large-scale planning of BGIs, such as restoring floodplains and using agricultural lands as buffer zones, is being prioritized to manage flood risks more sustainably than traditional "grey" systems alone. • Adaptive Planning: Moving away from prescriptive, top-down models toward community-driven, flexible strategies that involve local stakeholders in decision-making. • Policy Integration: Effective 2025 frameworks emphasize the need for cross-scale and intersectoral planning that recognizes peri-urban areas as integrated systems rather than disconnected fringes		

Table 15: Exposure, vulnerability and impacts of changes in precipitation patterns on urban elements

Hazard: CHANGES 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
Water & Wastewater Management	• Malaba municipality is served by BUWASCO which provides water and	Low	**Sensitivity:** • Aging infrastructure •	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	sewer services. Some dwellers are not connected to the grid because they have dug their own wells and sewers and toilets • The municipality boasts of a modern sewer line with a treatment facility. The only challenge is that it does serve just a small portion of the community as most dwellers have dug their own septic pits in their homes.		**Adaptive Capacity:** • Integrating flexibility, redundancy, and modernization into infrastructure and governance		
Solid Waste Management	• The municipality hosts a dumpsite which receives solid waste from the whole county. This is done through a public – private partnership. Trucks deliver the waste every day. • The municipality does not have properly designated waste collection points. We have areas where the waste is dumped and collected from, for example, at Malaba CBD area. • The trucks are not modernized, exposing workers to health risks.	Low	**Sensitivity:** • Heavy rain saturates waste, generating more leachate, which can overflow the landfill dumpsite, contaminating soil and water. • Rain can increase the moisture content and bulk of waste, affecting processing and transport efficiency. **Adaptive Capacity:** • Key strategies include upgrading infrastructure (e.g., better drainage, higher landfill liners), improving operational flexibility (e.g., emergency collection routes), and fostering institutional learning.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Transport and Mobility	• Malaba municipality boasts of a robust transport and mobility channel, many roads and feeder roads are tarmacked while others are all weather roads.	Low	**Sensitivity:** • Intense rain can wash out roads in low lying areas, damage bridge foundations and drainage channels like at Ikapoloko, and inundate tunnels and rail lines, requiring costly repairs. • Damaged routes disrupt the movement of goods, impacting businesses and essential supplies. **Adaptive Capacity:** • Involves building resilience against increased flashfloods, and infrastructure degradation through enhanced design standards, operational flexibility, and nature-based solutions.	Low	Minor
Energy	• There is an electricity substation within the municipality along the Bungoma Malaba Route • Most municipal dwellers use electricity and are connected to the power grid	Low	**Sensitivity:** • Changes in precipitation patterns can lead to frequent power cuts which affect businesses and peoples lifestyles. **Adaptive Capacity:** • Diversifying energy sources, upgrading infrastructure (e.g., storm hardening), improving water management, and leveraging technology like smart grids.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Economic Infrastructure	• Key components of our municipal economic infrastructure include; roads, railway, electricity lines,	Low	**Sensitivity:** • Heavy precipitation overwhelms storm water sewage systems and increases the risk of urban flooding. Conversely, prolonged droughts reduce water availability for municipal and industrial use. • Increased moisture leads to erosion, which directly impacts the maintenance costs and lifespan of roads and buildings. **Adaptive Capacity:** • Building resilience through infrastructure upgrades (e.g., better drainage, renewable energy, low-carbon transport).	Low	Minor
Social Infrastructure	• Our social infrastructure in the municipality includes; many hospitals, schools, housing, a prison, banks markets among many other facilities.	Low	**Sensitivity:** • Increased flooding leads to structural failures in buildings, including peeling paint, stained walls, and total collapse. Inadequate drainage and poor-quality housing, such as mud houses, fail to protect residents from severe weather. • Destruction of critical facilities. • Negative impact to housing and settlements. • Vulnerable populations are mostly affected.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Institutional planning (like the National Adaptation Plan) and community-identified strategies (drought-resistant crops, tree planting) • Integrated solutions like early warning, diversified livelihoods, and robust social support for resilient social infrastructure.		
Emergency Services	• Malaba municipality has a range of emergency services that include hospital ambulances, police services, social services offered by Red Cross.	Low	**Sensitivity:** • Flooding elevates the risk of waterborne diseases like cholera and malaria, placing additional stress on healthcare systems. • Extended droughts increase cardiovascular issues due to extreme heat and respiratory problems from dust/particulate matter.	Low	Minor
			Adaptive Capacity: • Stronger integration of disaster risk reduction, improved data sharing, capacity building, and multi-sectoral collaboration to enhance preparedness for health crises (dengue, cholera) and climate-induced disasters.		
Populations					
Urban Residents	• Municipal population as of 2019 census stands at 102,246 41% of this population is found	Low	**Sensitivity:** • Water Shortages and Utility Disruptions. • High awareness but limited effective action.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	within the urban areas		**Adaptive Capacity:** • Need for better governance, community participation, and integrating disaster risk Reduction into urban planning.		
Informal Settlement Residents	• Approximately **102,246 people** living in informal settlements within Malaba Municipality	Low	**Sensitivity:** • Poor infrastructure, insecure tenure, and often exclusion from formal planning. **Adaptive Capacity:** • Inclusivity Involve residents in planning. • Contextualized Finance: Link formal climate funds to community-level projects. • Capacity building: Strengthen neighborhood-level skills and education. • **Mixed adaptation:** Combine formal (e.g., flood defenses) with local solutions (NbS, social networks).	Low	Minor
Vulnerable and Marginalized Groups	• This group includes; women (GBV), monetarily poor, PWDs, the elderly,	Low	**Sensitivity:** • Widening income gaps, destroying livelihoods, and reducing food security.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	PLWHIV among others		**Adaptive Capacity:** • Using community-led Vulnerability & Capacity Assessments (VCA) helps identify local needs and design context-specific actions. • Savings clubs, mobile money, and access to rural banks build financial resilience, enabling purchases like water tanks. • Investing in water management, early warning systems, and disseminating better climate information are crucial. • Integrating traditional practices with modern strategies enhances local responses.		
Natural Assets		Low			

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Urban Green Infrastructure	• Along transport corridors for example Simba street.	Low	**Sensitivity:** • Changes in precipitation, like more intense downpours and droughts, challenge urban green infrastructure (UGI) by overwhelming drainage (flooding) or stressing plants (drought), reducing UGI's ability to cool, manage storm water, and support biodiversity, necessitating climate-proof designs like drought-resistant planting, better irrigation, and integrated green-gray systems to maintain vital ecosystem services and municipal resilience. **Adaptive Capacity:** • Integrated approach. • Community led approaches. • Research and monitoring.	Low	Minor
Urban Blue Infrastructure	• Including rivers Malakisi and Komiriai	Low	**Sensitivity:** • Changes in precipitation patterns significantly impact urban blue infrastructure (UBI)—such as ponds, wetlands, rivers, and constructed retention basins—by alternating between extreme overloading during heavy rainfall and reduced functionality during droughts. Increased intensity and frequency of extreme rainfall lead to hydraulic overload, reduced water quality, and flash floods **Adaptive Capacity:** • Nature based solutions.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Peri-urban and Agricultural Systems	• Characterized by subsistence farmers, dairy farmers, horticulture(vegetables), in all wards • There is significant uncontrolled sprawl of urban areas into prime agricultural land. The municipality is experiencing land fragmentation, leading to smaller, less Economical landholdings.	Low	**Sensitivity:** • Decline in crop production and yield, livestock stress, • Food insecurity • **Adaptive Capacity:** • Climate smart agriculture		Minor

Table 16: Exposure, Vulnerability and impacts of extreme heat on urban elements

Hazard: EXTREME HEAT

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					
Storm water Drainage	• The municipality boasts of a robust storm water drainage channel, guided by the natural drainage and leads most of the waters to river Malakisi • Some of the drainage channels have suffered infrastructure damage, for	Low	**Sensitivity:** • Extreme heat intensifies storm water issues by speeding up the water cycle, leading to more intense downpours that overwhelm pipes, causing increased flooding, erosion, and pollution	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	Example in Malaba town.		**Adaptive Capacity:** • Regular maintenance of storm water drainage channels. • Integrated Urban Water Management (IUWM): Adopting holistic planning that treats storm water as a resource for irrigation and groundwater recharge helps manage multiple stresses (drought, heat, flood) simultaneously.		
Water & Wastewater Management	• Malaba municipality is served by BUWASCO which provides water and sewer services. Some dwellers are not connected to the grid because they have dug their own wells and sewers and toilets • The municipality boasts of a modern sewer line with a treatment facility. The only challenge is that it does serve just a small portion of the community as most dwellers have dug their own septic pits in their homes.	Low	**Sensitivity:** • Increased demand for water. • Increased operational costs. **Adaptive Capacity:** • Infrastructure upgrade • Utilizing urban water bodies and vegetation to provide natural cooling, this reduces demand on municipal water supplies for cooling purposes.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Solid Waste Management	• The municipality hosts a dumpsite which receives solid waste from the whole county. This is done through a public – private partnership. Trucks deliver the waste every day. • The municipality does not have properly designated waste collection points. We have areas where the waste is dumped and collected from, for example, at Malaba CBD. • The trucks are not modernized, exposing workers to health risks.	Low	**Sensitivity:** • Extreme heat severely impacts solid waste management by accelerating decomposition, worsening odors, increasing pests, heightening fire risks (even spontaneous combustion), stressing infrastructure, disrupting machinery, and creating significant health hazards for workers and communities through poor air/water quality, leading to increased costs and operational challenges **Adaptive Capacity:** • Landfill management; increased compaction to prevent fires. • Utilizing covered trucks, underground waste containers, and well-ventilated sorting facilities.	Low	Minor
Transport and Mobility	• Malaba municipality boasts of a robust transport and mobility channel, many roads and feeder roads are tarmacked while others are all weather roads.	Low	**Sensitivity:** • Extreme heat severely impacts transport by damaging infrastructure (buckling rails/roads, sagging power lines **Adaptive Capacity:** • Using materials in road construction that can better withstand extreme temperatures without melting or warping. • Designing shaded and green, dense urban environments to lower ambient temperatures for pedestrians and cyclists.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Energy	• There is an electricity substation within the municipality along the Bungoma Malaba Route • Most municipal dwellers use electricity and are connected to the power grid	Low	**Sensitivity:** • Extreme heat strains energy systems by dramatically increasing cooling demand while simultaneously reducing power generation and transmission efficiency, leading to higher costs, pollution and increased blackouts as power plants, transmission lines, and renewable sources (like solar) perform poorly in high temperatures, causing grid instability. **Adaptive Capacity:** • Ensuring reliable, affordable electricity for cooling is crucial.	Low	Minor
Economic Infrastructure	• Key components of our municipal economic infrastructure include; roads, railway, electricity lines,	Low	**Sensitivity:** • Extreme heat cripples economic infrastructure by damaging physical assets (roads melting, power lines sagging), disrupting energy grids (reduced efficiency, blackouts), crippling transportation (buckled rails), and reducing labor productivity across sectors like construction, agriculture, and manufacturing, leading to massive economic losses, supply chain breakdowns, and increased costs for adaptation and repair •	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Greening our town (trees, cool roofs), improving building designs, cooling public infrastructure. • Strengthening community networks and awareness programs to help vulnerable populations.		
Social Infrastructure	• Our social infrastructure in the municipality includes; many hospitals, schools, housing, a prison, banks markets among many other facilities.	Low	**Sensitivity:** • disproportionately harms vulnerable populations, reduced productivity, and potential social unrest due to failures in essential services like water and power • **Adaptive Capacity:** • Planting trees and creating parks to reduce urban heat island effects. • Integrating heat adaptation into urban planning, focusing on high-risk areas and vulnerable populations.	Low	Minor
Emergency Services	• Malaba municipality has a range of emergency services that include hospital ambulances, police services, social services offered by Red Cross.	Low	**Sensitivity:** • exacerbating chronic conditions (cardiovascular, respiratory), leading to overwhelmed Emergency Departments • Vulnerable groups (elderly, very young, pre-existing conditions, low-income) suffer most, increasing overall strain. •	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Strategic planning that strengthens infrastructure, improves personnel resilience, and enhances community engagement		
Populations					
Urban Residents	• Municipal population as of 2019 census stands at 102246.	Low	**Sensitivity:** • Extreme heat in cities causes severe health issues like heatstroke, dehydration, and organ strain, worsening chronic conditions (heart, respiratory, kidney), disrupting sleep. **Adaptive Capacity:** • Expanding green infrastructure (parks, urban forests) and improving building codes for heat resilience.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Informal Settlement Residents	• Approximately **102,246 people** living in informal settlements within Malaba Municipality	Low	**Sensitivity:** • Extreme heat severely impacts informal settlement residents through increased heat-related illnesses (dehydration, respiratory issues, heat stroke), reduced income from disrupted livelihoods (street vending, construction), worsened psychological distress, and higher mortality • Reduced workdays and productivity for outdoor laborers (vendors, construction) due to heat stress. • Dwellings (mud) trap heat, with poor ventilation, and offer poor insulation, leading to extremely high indoor temperatures. • **Adaptive Capacity:** • Better urban planning and data collection that includes informal settlements to target interventions. • Increasing green/blue spaces (trees, water bodies).	Low	Minor
Vulnerable and Marginalized Groups	• This group includes; women (GBV), monetarily poor, PWDs, the elderly, PLWHIV among others	Low	**Sensitivity:** • Inability to afford cooling, lost workdays, or difficulties accessing services due to heat-damaged infrastructure.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
			Adaptive Capacity: • Creating awareness. • Better urban planning and data collection that includes informal settlements to target interventions. • Increasing green/blue spaces (trees, water bodies).		
Natural Assets					
Urban Green Infrastructure	• Along transport corridors for example Simba street	Low	**Sensitivity:** • Extreme heat stresses urban green infrastructure (UGI) by increasing water demand, potentially degrading plant health, and reducing cooling effectiveness **Adaptive Capacity:** • Increasing the size of urban green infrastructure • Combine green, blue, and grey infrastructure (like cool pavements) for synergistic effects.	Low	Minor
Urban Blue Infrastructure	• Including river malakisi and Komiriai	Low	**Sensitivity:** • Extreme heat challenges urban blue infrastructure (water bodies, drainage) by increasing water demand. **Adaptive Capacity:** • Maintaining and improving urban blue infrastructure to maximize its benefits.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Peri-urban and Agricultural Systems	• Characterized by subsistence farmers, dairy farmers, horticulture(vegetables), in areas all wards • There is significant uncontrolled sprawl of urban areas into prime agricultural land. The municipality is experiencing land fragmentation, leading to smaller, less economical landholdings.	Low	**Sensitivity:** • Extreme heat poses a critical, systemic threat to both peri-urban and agricultural systems, acting as a "risk multiplier" that compounds vulnerabilities in water, food, Energy, and labor. **Adaptive Capacity:** • Water management. • Agronomic adjustments.	Low	Minor

Table 17: Exposure, vulnerability and impacts of average surface temperature increase on urban elements.

Hazard: AVERAGE SURFACE TEMPERATURE INCREASE

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Infrastructure & Services					
Storm water Drainage	• The municipality boasts of a robust storm water drainage channel, guided by the natural drainage and leads most of the waters to river Malakisi • Some of the drainage channels have suffered infrastructure damage, for example near the county referral hospital	Low	**Sensitivity:** • Increased average surface temperatures due to global warming profoundly affect municipal storm water drainage by accelerating the hydrological cycle, leading to more intense, frequent, and flashier rain events that exceed the design capacity of traditional Infrastructure. **Adaptive Capacity:** • Solutions like bioswales, rain gardens, and permeable pavements can reduce runoff volume by up to 99% in some scenarios, specifically acting as filters and Retention areas.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Water & Wastewater Management	• Malaba municipality is served by BUWASCO which provides water and sewer services. Some dwellers are not connected to the grid because they have dug their own wells and sewers and toilets • The municipality boasts of a modern sewer line with a treatment facility. The only challenge is that it does serve just a small portion of the community as most dwellers have dug their own septic pits in their homes.	Low	**Sensitivity:** • Rising average surface temperatures significantly impact municipal water and wastewater management by reducing treatment efficiency, accelerating infrastructure deterioration, and shifting Demand patterns. **Adaptive Capacity:** • Infrastructure upgrades. • Green infrastructure • Water management practices.	Low	Minor
Solid Waste Management	• The municipality hosts a dumpsite which receives solid waste from the whole county. This is done through a public – private partnership. Trucks deliver the waste every day. • The municipality does not have properly designated waste collection points. We have areas where the waste is dumped and collected from, for example, at Malaba CBD. • The trucks are not modernized, exposing workers to health risks.	Low	**Sensitivity:** • Key impacts include increased odor, faster waste generation due to food spoilage, and heightened risks of spontaneous landfill fires at Kajei Dumpsite. **Adaptive Capacity:** • Infrastructure upgrades. • Technology integration.	Low	Minor
Transport and Mobility	• Most of our roads are tarmacked and a few are all weather roads.	Low	**Sensitivity:** • Damaging infrastructure like softening asphalt, disrupting services.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	• Malaba municipality boasts of a robust transport and mobility channel, many roads and feeder roads are tarmacked while others are all weather roads.		**Adaptive Capacity:** • Nature-Based Solutions: Planting trees and installing green roofs to reduce the urban heat island effect, which lowers ambient temperatures around transit infrastructure. • Material Upgrades: Using higher-grade, heat-resistant asphalt and materials with lower thermal expansion coefficients for rail.		
Energy	• There is an electricity substation within the municipality along the Bungoma Malaba Route • Most municipal dwellers use electricity and are connected to the power grid	Low	**Sensitivity:** • A significant surge in electricity demand for cooling and increased stress on energy infrastructure. **Adaptive Capacity:** • Infrastructure Resilience. • Resource Diversification.	Low	Minor
Economic Infrastructure	• Key components of our municipal economic infrastructure include; roads, railway, electricity lines,	Low	**Sensitivity:** • High temperatures significantly lower worker productivity, particularly in outdoor sectors like construction and agriculture And outdoor businesses. **Adaptive Capacity:** • Improved engineering standards. • Material upgrades • Nature based solutions • Maintenance.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Social Infrastructure	• Our social infrastructure in the municipality includes; many hospitals, schools, housing, a prison, banks markets among many other facilities	Low	**Sensitivity:** • Facilities and systems that support human life, health, and community cohesion (e.g., healthcare, education, housing, water, and transport). Rising temperatures threaten to buckle, break, or degrade these systems. **Adaptive Capacity:** • Green Infrastructure. • Technological Adaptation. • Social protection. • Policy and Planning.	Low	Minor
Emergency Services	• Malaba municipality has a range of emergency services that include hospital ambulances, police services, social services offered by Red Cross.	Low	**Sensitivity:** • Key impacts include a rise in heat-related illnesses (heatstroke, dehydration), exacerbation of chronic conditions (cardiovascular and respiratory distress), and increased fire incidents due to drier Conditions. **Adaptive Capacity:** • Infrastructure & Equipment Retrofitting. • Workforce Protection	Low	Minor
Populations					
Urban Residents	• Municipal population as of 2019 census stands at 102,246	Low	**Sensitivity:** • Severe health risks and increased mental stress to higher energy costs and reduced Productivity. **Adaptive Capacity:** • Technological/Mechanical Cooling. • Structural Modifications.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Informal Settlement Residents	• Approximately **102,246 people** living in informal settlements within Malaba Municipality	Low	**Sensitivity:** • Extreme health risks, reduced economic productivity, and limited adaptive Capacity. **Adaptive Capacity:** • Nature-Based Solutions. • Community-Led Data.	Low	Minor
Vulnerable and Marginalized Groups	• This group includes; women (GBV), monetarily poor, PWDs, the elderly, PLWHIV among others	Low	**Sensitivity:** • Exacerbated existing inequalities, leading to severe health, economic, and social consequences. These populations—including low-income households, indigenous peoples, the elderly, children, and outdoor workers—face the worst consequences, such as heat-related illnesses, food insecurity, and Displacement. **Adaptive Capacity:** • Coping Mechanisms. • Social Capital.	Low	Minor
Natural Assets					
Urban Green Infrastructure	• Along transport corridors for example Simba street	Low	**Sensitivity:** • Increasing plant water needs, reducing cooling efficacy during droughts, and damaging infrastructure like roots and Soil. **Adaptive Capacity:** • Combining Infrastructure. • Species Selection.	Low	Minor

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Urban Blue Infrastructure	• Including river malakisi	Low	**Sensitivity:** • Degrading water quality, and shrinking their spatial extent • • **Adaptive Capacity:** • Increase size and structure. • Restoring degraded wetlands and combining with green infrastructure.	Low	Minor
Peri-urban and Agricultural Systems	• Characterized by subsistence farmers, dairy farmers, horticulture (vegetables), in all wards there is significant uncontrolled sprawl of urban areas into prime agricultural land. The municipality is experiencing land fragmentation, leading to smaller, less economical landholdings.	Low	**Sensitivity:** • Reducing productivity, increasing resource scarcity, and threatening food security. In peri-urban areas, this is often intensified by the **urban heat island (UHI) effect**, where impervious surfaces store and re-emit heat, creating temperatures significantly higher than Surrounding rural areas. **Adaptive Capacity:** • Crop Changes, Water Management, Livestock Management, Urban-Specific Measures.	Low	Minor

4. Climate Risk Assessment

This chapter serves as the analytical core of this assessment, translating the climatic projections and community vulnerabilities established in previous chapters into a clear evaluation of specific climate risks facing Malaba Municipality. This chapter systematically identifies, characterizes, and prioritizes the key climate hazards such as flashfloods, extreme heat, and changes in surface temperature and analyzes their interaction with the Municipality's exposed assets and vulnerable systems. By integrating the climate exposure data with sensitivity and adaptive capacity factors, the assessment produces a prioritized risk profile. This foundational analysis provides the critical evidence base to inform the subsequent development of targeted adaptation and resilience strategies in Chapter 5.

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

Table 18: Risk Matrix

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

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

Table 19: interpretation of risk levels

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

4.1. Current and Future Climate Risks on Urban Elements

Table 20: Summary of pluvial flooding risks for Malaba Municipality

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level	low	low	Low	low	low
Categories	**Impact**	**Risk Levels**				
		Current	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Infrastructure & Services						
Storm water Drainage	minor	Low	low	Low	Low	low
Water & Wastewater Management	minor	Low	Low	Low	Low	Low
Solid Waste Management	minor	Low	Low	Low	Low	Low
Transport and Mobility	minor	Low	Low	Low	Low	Low
Energy	minor	Low	Low	Low	Low	Low
Economic Infrastructure	minor	Low	Low	Low	Low	Low
Social Infrastructure	minor	Low	Low	Low	Low	Low
Emergency Services	minor	Low	Low	Low	Low	Low
Populations						
Urban Residents	minor	Low	Low	Low	Low	Low
Informal Settlement Residents	minor	Low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	medium	Low	Low	Low	Low	Low
Natural Assets						
Urban Green Infrastructure	minor	Low	Low	Low	Low	Low
Urban Blue Infrastructure	minor	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	minor	Low	Low	Low	Low	Low

Table 21: Summary of changes in precipitation patterns risks for Malaba Municipality

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level	low	low	Low	low	Low
Categories	**Impact**	**Risk Levels**				
		Current	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Infrastructure & Services						

Storm water Drainage	minor	Low	Low	Low	Low	Low
Water & Wastewater Management	minor	Low	Low	Low	Low	Low
Solid Waste Management	minor	Low	Low	Low	Low	Low
Transport and Mobility	minor	Low	Low	Low	Low	Low
Energy	minor	Low	Low	Low	Low	Low
Economic Infrastructure	minor	Low	Low	Low	Low	Low
Social Infrastructure	minor	Low	Low	Low	Low	Low
Emergency Services	minor	Low	Low	Low	Low	Low
Populations						
Urban Residents	Minor	Low	Low	Low	Low	Low
Informal Settlement Residents	Minor	Low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	Minor	Low	Low	Low	Low	Low
Natural Assets						
Urban Green Infrastructure	Minor	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Minor	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	Minor	Low	Low	Low	Low	Low

Table 22: Summary of extreme heat risks for Malaba Municipality

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level	low	low	Low	low	Low
Categories	**Impact**	**Risk Levels**				
		Current	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Infrastructure & Services						
Storm water Drainage	Minor	Low	Low	Low	Low	Low
Water & Wastewater Management	Minor	Low	Low	Low	Low	Low
Solid Waste Management	Minor	Low	Low	Low	Low	Low
Transport and Mobility	Minor	Low	Low	Low	Low	Low
Energy	Minor	Low	Low	Low	Low	Low
Economic Infrastructure	Minor	Low	Low	Low	Low	Low
Social Infrastructure	Minor	Low	Low	Low	Low	Low
Emergency Services	Minor	Low	Low	Low	Low	Low
Populations						

Urban Residents	Minor	Low	Low	Low	Low	Low
Informal Settlement Residents	Minor	Low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	Minor	Low	Low	Low	Low	Low
Natural Assets						
Urban Green Infrastructure	Minor	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Minor	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	Minor	Low	Low	Low	Low	Low

Table 23: Summary of average surface temperature increase risks for Malaba municipality

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level	low	low	Low	low	low
Categories	**Impact**	**Risk Levels**				
		Current	**2050 SSP2-4.5**	**2050 SSP5-8.5**	**2100 SSP2-4.5**	**2100 SSP5-8.5**
Infrastructure & Services						
Storm water Drainage	Minor	Low	Low	Low	Low	Low
Water & Wastewater Management	Minor	low	Low	Low	Low	Low
Solid Waste Management	Minor	Low	Low	Low	Low	Low
Transport and Mobility	Minor	Low	Low	Low	Low	Low
Energy	Minor	Low	Low	low	Low	Low
Economic Infrastructure	Minor	Low	low	Low	Low	Low
Social Infrastructure	Minor	Low	Low	Low	Low	Low
Emergency Services	Minor	Low	Low	Low	Low	Low
Populations						
Urban Residents	Minor	Low	Low	Low	Low	Low
Informal Settlement Residents	Minor	low	Low	Low	Low	Low
Vulnerable and Marginalized Groups	Minor	Low	Low	Low	Low	Low
Natural Assets						
Urban Green Infrastructure	Minor	Low	Low	Low	Low	Low
Urban Blue Infrastructure	Minor	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	Minor	Low	Low	Low	Low	low

4.2. Climate Risk Hotspots

Climate risks are not uniformly distributed across the municipality. Their spatial distribution is influenced by topography, land use, settlement patterns, infrastructure density, and socio-economic vulnerability. Below is a narrative explanation of how these risks vary across different parts of Malaba, incorporating insights from current conditions and future climate projections under SSP2-4.5 and SSP5-8.5 scenarios.

Current Risk Distribution (Baseline)

1. Malaba central Ward

- **Primary Hazards:** Pluvial flooding, extreme heat
- **Exposure:** Informal settlements (low-lying areas near River Malakisi, poorly drained feeder roads.
- **Vulnerability:** High population density, low-income households, inadequate drainage, informal housing.
- **Impacts:** Frequent flash flooding, water contamination, disruption of mobility, health risks from heat and waterborne diseases.
- **Why:** Located along river valleys and natural drainage paths, with rapid unplanned development and limited infrastructure.

2. Malaba south Ward

- **Primary Hazards:** Extreme heat, pluvial flooding in low-lying zones
- **Exposure:** High-density commercial and residential areas, key infrastructure (hospitals, markets, county offices).
- **Vulnerability:** Aging drainage in some areas, high impervious surfaces, urban heat island effect.
- **Impacts:** Heat stress among outdoor workers and market vendors, localized flooding in underserviced areas (e.g., near County Referral Hospital).
- **Why:** Urbanized core with concentrated assets but some infrastructure gaps.

3. Other Wards in municipality

- **Primary Hazards:** Changes in precipitation patterns, average temperature increase
- **Exposure:** Peri-urban agricultural systems, rural homesteads, dispersed settlements.
- **Vulnerability:** Reliance on rain-fed agriculture, limited irrigation, soil degradation.
- **Impacts:** Crop failure, livestock stress, reduced household income, food insecurity.
- **Why:** Economically dependent on climate-sensitive agriculture with low adaptive capacity.

Future Risk Distribution under Climate Projections

Mid-Term (2050) – SSP2-4.5 & SSP5-8.5

- **Malaba central Ward:**
    - Flood risk intensifies due to increased rainfall intensity.

    - Heatwaves become more frequent, exacerbating health risks in densely populated informal areas.
    - Drainage systems become increasingly overwhelmed.
- **Malaba south Ward:**
    - Urban heat island effect worsens, increasing energy demand for cooling.
    - Flash flooding may increase along clogged or undersized drains.
    - Infrastructure stress rises, especially on roads and water systems.
- **Other Wards within Municipality**
    - Erratic rainfall disrupts planting seasons, affecting maize and vegetable yields.
    - Temperature rise reduces soil moisture, increasing irrigation needs.
    - Risk of agricultural decline pushes more residents into informal settlements in Malaba South.

Long-Term (2100) – SSP5-8.5 (High Emissions Scenario)

- **Malaba central Ward:**
    - **Very High Risk** – Flooding becomes more severe and frequent; some areas may become near-uninhabitable without intervention.
    - Extreme heat days increase significantly, posing severe public health risks.
    - Informal settlements face compounding crises: flooding + heat + disease.
- **Malaba south Ward:**
    - **High Risk** – Critical infrastructure (energy, health, transport) faces recurrent disruption.
    - Prolonged heatwaves strain emergency services and water supply.
    - Economic losses mount due to business interruptions and infrastructure damage.
- **Amukura west Ward:**
    - **High Risk** – Agricultural viability declines significantly, leading to livelihood loss and migration.
    - Increased temperature reduces pasture and crop productivity.
    - Food security becomes a major municipal concern.

5. What's Next?

5.1. Key Findings

Table 24: Summary of climate risks affecting urban elements for malaba Municipality

Category	List of Key Hazards		
	Current	**Mid-term (2050)**	**Long-term (2100)**
Infrastructure & Services			
Stormwater Drainage	▪ Pluvial flooding ▪ Extreme heat	▪ Pluvial flooding ▪ Extreme heat	▪ Pluvial flooding ▪ Extreme heat ▪ Changes in precipitation patterns
Water & Wastewater Management	Changes in precipitation patterns	Changes in precipitation patterns	Changes in precipitation patterns
Solid Waste Management	Changes in precipitation patterns	Changes in precipitation patterns	Changes in precipitation patterns
Transport and Mobility	Pluvial flooding	Pluvial flooding	Pluvial flooding
Energy	Extreme heat Changes in precipitation patterns	Extreme heat Changes in precipitation patterns	Extreme heat Changes in precipitation patterns
Economic Infrastructure	Pluvial flooding	Pluvial flooding	Pluvial flooding
Social Infrastructure	Pluvial flooding Average surface temperature increase	Pluvial flooding Average surface temperature increase	Pluvial flooding Average surface temperature increase
Emergency Services	Pluvial flooding Average surface temperature increase	Pluvial flooding Average surface temperature increase	Pluvial flooding Average surface temperature increase
Populations			
Urban Residents	Extreme heat Changes in precipitation patterns	Extreme heat Changes in precipitation patterns Pluvial flooding	Extreme heat Changes in precipitation patterns Pluvial flooding
Informal Settlement Residents	Pluvial flooding Extreme heat	Pluvial flooding Extreme heat	Pluvial flooding Extreme heat
Vulnerable and Marginalized Groups	Pluvial flooding Extreme heat Changes in precipitation patterns	Pluvial flooding Extreme heat Changes in precipitation patterns	Pluvial flooding Extreme heat Changes in precipitation patterns
Natural Assets			

Category	List of Key Hazards		
	Current	**Mid-term (2050)**	**Long-term (2100)**
Urban Green Infrastructure	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding
Urban Blue Infrastructure	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding
Peri-urban and Agricultural Systems	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding	Average surface temperature increase Extreme heat Pluvial flooding

Based on the completed hazard matrix, the climate risk assessment for Malaba Municipality reveals several critical and persistent takeaways:

1. Pervasive and Intensifying Core Hazards: The Municipality faces a consistent and escalating threat from pluvial (surface water) flooding and extreme heat across all time horizons. These are not isolated issues but systemic risks impacting virtually every category, from infrastructure and services to populations and natural assets.

2. Universal Vulnerability of Infrastructure: All infrastructure and service systems are exposed, with storm water drainage, transport, economic, and social infrastructure being particularly vulnerable to flooding, while energy systems and water management face compounding pressures from both heat and changing rainfall patterns. This indicates widespread risk to the Municipality's foundational systems.

3. Acute Risk for Vulnerable Populations: Informal settlement residents and marginalized groups are disproportionately exposed to the primary hazards of flooding and extreme heat, often compounded by pre-existing socio-economic vulnerabilities. This highlights a critical equity dimension to the climate risk.

4. Threat to Natural and Food Systems: The urban green/blue infrastructure and peri-urban agricultural systems—vital for cooling, drainage, food security, and livelihoods—are themselves under threat from the same hazards they help mitigate, particularly heat and flooding, creating a negative feedback loop.

5. Long-Term Expansion of Risks: While the core hazards remain constant, the long-term (2100) projection introduces "changes in precipitation patterns" as a direct hazard to storm water drainage, signaling a future where both rainfall variability and intensity may overwhelm existing planning parameters.

Overall, the assessment paints a picture of a Municipality where key climate hazards are deeply interconnected, threatening both its built environment and its most vulnerable people simultaneously, with risks set to intensify over the coming decades.

5.2. Climate Adaptation and Resilience Solutions

Table 25: Climate adaptation and resilience solutions recommended for Bungoma Municipality

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Infrastructure & Services			
Storm water Drainage	• **Structural** • Drainage cleaning and clearing • Upsizing key pipes • **Non structural** • Public Education Campaigns • Street Sweeping • **Nature based solutions** • Tree Planting • Installing containers to capture roof runoff for reuse	• **Structural** • Permeable pavement • Hydronamic separators • **Non structural** • Land-Use Regulations • Downspout Disconnection Programs • **Nature based solutions** • Constructing vegetated channels along roadsides to slow, filter, and infiltrate runoff. • Creating shallow, landscaped depressions with native plants to soak up rainwater.	• **Structural** • System overhaul • Smart drainage systems • **Non structural** • Water Sensitive Urban Design (WSUD) • Storm water Utility Fees • Adaptive Management Plans • **Nature based solutions** • Creating or restoring wetlands to filter pollutants and attenuate flood peaks. • Urban Forest Expansion: Large-scale re-vegetation to increase soil water retention.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Water & Wastewater Management	• **Structural** • Install mobile water treatment units for flood events, deploy temporary water tanks during droughts, and upgrade flood defenses for critical, high-risk assets. • **Non structural** • Implement water rationing during shortages, establish early warning systems for floods/droughts, and develop contingency plans for rapid response. • **Nature based solutions** • Restore degraded riparian buffers along rivers to reduce erosion, and implement small-scale community-based erosion control. •	• **Structural** • Construct rainwater harvesting systems, expand wastewater reuse infrastructure, and build small-to-medium-sized reservoirs for storage • **Non structural** • Update building codes and zoning regulations to prohibit development in high-risk zones, and implement "no-regrets" water pricing to encourage conservation. • **Nature based solutions** • Construct wetlands to filter pollutants from urban runoff, implement green roofs in cities to reduce heat island effects and storm runoff, and initiate reforestation Projects in watersheds.	• **Structural** • Redesign entire urban water systems, build large-scale desalination plants for coastal cities, and reinforce sewage treatment plants against sea-level rise. • **non structural** • Integrate climate projections into land-use planning, develop cross-sectoral water governance frameworks, and establish transboundary water agreements. • **nature based solutions** • Implement large-scale floodplain restoration ("Room for the River" approach),

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Solid Waste Management	• **Structural** • Ensure landfill leachate collection systems have enough capacity to handle heavy rainfall. • **Non structural** • Create disaster waste management plans for debris removal and safe disposal. • Launch campaigns to encourage source separation and reduce littering. • **Nature based solutions** • Initiate separate collection of organic waste to reduce methane in landfills. • Stabilize slopes on dump sites using vegetation to prevent landslides.	• **Structural** • Build decentralized organic waste treatment plants to reduce transport distances and fire risk • Install sealed or covered containers to prevent waste from drifting away during extreme wind. • Apply covers to reduce leachate generation. • **non structural** • Implement Extended Producer Responsibility (EPR) policies to encourage design for recycling • Use sensors to monitor landfill temperature and gas emissions. • **nature based solutions** • Use constructed wetlands to store and treat leachate and contaminated run-off. • Utilize stabilized landfill waste to create engineered soil for erosion control.	• **Structural** • Implement incineration or advanced WTE technologies to reduce landfill reliance. • Redesign all waste facilities to withstand extreme climate projections over their lifetime • **non structural** • Shift to a zero-waste economy with a focus on product lifecycle, repair, and reuse. • Move waste facilities out of high-risk zones (e.g., floodplains). • **nature based solutions** • Large-scale restoration of wetlands and forests around waste sites to provide natural buffering.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Transport and Mobility	• **Structural** • Installing "cool pavements" and heat-resistant materials (e.g., more durable asphalt) to prevent road buckling. • Regular auditing and cleaning of drains to handle increased run-off from intense rainfall. • Increased maintenance to ensure visibility in dusty or sandy conditions. • **Non structural** • Implementing systems to forecast storms and extreme heat for better disaster risk management. • Gathering data on weather impacts to prioritize future actions. • **Nature based solutions** • Planting trees and vegetation to provide shade, reduce the urban heat island effect, and stabilize soil. • Clearing waterways and drainage channels of debris to reduce flood risk.	• Structural • Raising critical roads and bridge expansion joints • Non structural • Revising infrastructure design codes to reflect future, more extreme climate projections. • Creating detailed vulnerability maps to identify high-risk areas. • Incorporating climate resilience into Urban Mobility Plans (SUMPs). • Natural based solutions • Integrating rain gardens, bioswales, and permeable pavements into streetscapes to manage storm water. •	• **Structural** • Building redundant transport networks to ensure connectivity if primary routes fail. • Large-scale replacement of critical infrastructure with highly durable materials designed for extreme scenarios. • **Non structural** • Restricting new developments in high-risk zones through stricter zoning regulations. • Ensuring all new infrastructure projects funded by governments are climate-proofed. • **Nature based solutions** • Establishing large-scale connected green spaces to mitigate city-wide heat island effects. • Restoring natural watercourses and floodplains to handle extreme water volumes.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Energy	• **Structural** • Installing storm-resistant poles, upgrading substations with waterproof casing (e.g., to withstand 1 meter of water for 30 mins), and installing physical barriers for flood protection. • **Non structural** • Developing emergency response, restoration, and contingency plans; implementing "demand-side management" to reduce loads during heatwaves. • **Nature based solutions** • Managing vegetation near power lines to reduce fire risks from falling trees. •	• **Structural** • Undergrounding distribution cables in high-fire risk or storm-prone areas, upgrading to heat-resistant conductor cables, and installing smart sensors for predictive maintenance • **Non structural** • Integrating climate risk into long-term infrastructure planning and investment decisions (e.g., in National Adaptation Plans), implementing performance-based regulation that incentivizes resilience. • **Nature based solutions** • Restoring coastal wetlands and mangroves to reduce storm surge damage to coastal power plants.	• **Structural** • Relocating critical infrastructure away from high-risk zones, upgrading thermal power plant cooling systems to use air or recycled water, and building redundant power transmission lines. • **Non structural** • Establishing regional interconnections to allow for electricity trade during local shortages, and implementing AI-based predictive analytics for climate hazards. • **Nature based solutions** • Using agroforestry and watershed management to stabilize slopes around hydro dams, reduce soil erosion, and regulate water flow.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Economic Infrastructure	• **Structural** • Deploying temporary flood barriers around critical substations and key transport hubs • Increasing capacity of culverts and storm drains in urban areas. • **Non structural** • Increasing frequency of inspections for aging infrastructure. • Developing rapid response protocols for business continuity during shutdowns. • **Nature based solutions** • Creating parks and open spaces to reduce urban heat island effects and absorb stormwater.	• **Structural** • Constructing dams and reservoirs to manage drought variability. • Using heat-resistant materials for roads to prevent melting and strengthening rail tracks to handle heat deformation. • **Non structural** • Updating building codes and engineering standards to reflect future climate projections rather than historical data. • Developing specialized insurance mechanisms for infrastructure. • **Nature based solutions** • Installing green roofs and permeable surfaces to facilitate infiltration and reduce sewage system strain.	• **Structural** • Integrating grey infrastructure with nature-based systems for maximum protection. • **non structural** • Mapping cascading failures across systems (e.g., how water failure impacts energy) to strengthen overall system design. • Implementing flexible, iterative plans that can be updated as climate science evolves • **nature based solutions** • Restoring forests to regulate water flow for water supplies.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Social Infrastructure	• **Structural** • Install backup generators for hospitals, improve ventilation with chimneys/slatted windows, apply reflective paint on roofs, and repair drainage systems. • **Non structural** • Develop and test contingency plans, establish early warning systems, secure emergency supplies, and train staff on climate-related health risks • **Nature based solutions** • Launch tree-planting campaigns for immediate shade, initiate community-led river clean-ups, and set up temporary or small-scale rain gardens.	• **Structural** • Retrofit buildings for energy efficiency, elevate critical infrastructure (e.g., electrical components) above flood levels, upgrade wastewater systems, and install solar panels. • **Non structural** • Implement land-use zoning to prevent building in high-risk zones, revise building codes for higher resilience standards, and establish shock-responsive social protection systems. • **Nature based solutions** • Install green roofs/facades on public buildings, develop bioswales and permeable pavements, and establish community urban gardens for food Security.	• **Structural** • Implement large-scale flood embankments, construct sea walls or surge barriers, and redesign entire urban drainage systems (e.g., "Sponge City" concepts) • **Non structural** • Relocate critical infrastructure from high-risk areas, integrate climate risk into long-term master planning, and update Financial models to factor in climate risks. • **Nature based solutions** • Large-scale mangrove/wetland restoration to act as storm buffers, reforestation of surrounding areas, and creating interconnected green corridors.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Emergency Services	• **Structural** • Installation of back-up generators and solar panels with battery storage at stations to ensure power during outages. • **Non structural** • Updating Emergency Action Plans (EAPs) to include climate-specific scenarios (e.g., compound events like drought followed by flood). • Conducting staff training on new climate-related protocols and PPE usage. • **Nature based solutions** • Deploying portable water storage for drought management.	• **Structural** • Retrofitting critical facilities with flood-resistant materials, elevated electrical systems, and reinforced roofing • Constructing redundant, fire-resistant, and elevated storage facilities for sensitive equipment and data. • **Non structural** • Revising zoning laws and building codes to prevent development in hazardous areas. • Creating community-based disaster risk reduction programs • **Nature based solutions** • Implementing urban greening initiatives, such as green roofs and rain gardens, to manage stormwater runoff and reduce the urban heat island effect on facilities.	• **Structural** • Hardening transportation networks (bridges, roads) to ensure emergency access during disasters. • Relocating or reconstructing critical emergency hubs (hospitals, dispatch centers) outside of high-risk flood or fire zones. • **Non structural** • Integrating climate risk assessments into all long-term urban planning and budgetary processes. • Developing data-driven predictive modeling for future climate threats. • Implementing insurance-based risk transfer mechanisms for infrastructure damage. • **Nature based solutions** • Constructing constructed wetlands for sustainable wastewater treatment. • Integrated watershed management to regulate water flow.
Populations			

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Urban Residents	• **Structural** • Install window shades, reflective roof coatings (cool roofs), and insulation to reduce indoor temperatures. Repair household drainage and install emergency water storage tanks. • **Non structural** • Establish community-based flood warning systems and heat emergency plans. Develop household emergency kits and evacuation plans. • Nature based solutions • Plant fast-growing shade trees around homes and set up small container gardens or balcony plants to reduce ambient temperatures.	• **Structural** • Upgrade household sanitation and waste management systems to prevent sewage overflow during floods. Retrofit homes with permeable pavements in driveways or yards • **Non structural** • Participate in community-led training on climate risks, disaster management, and environmental conservation. Implement rainwater harvesting systems for irrigation and cleaning. • **Nature based solutions** • Install green roofs or vertical gardens on building exteriors to improve insulation and reduce heat. Develop community Kitchen gardens for food security.	• **Structural** • Deeply retrofit buildings with advanced materials to withstand extreme weather • **Non structural** • Advocacy for updated zoning regulations that steer development away from risk zones and mandate green infrastructure. Integration into circular economy practices (waste-to-wealth programs). • **Nature based solutions** • Restore local wetlands, rivers, and mangrove forests to act as natural buffers against flooding and sea-level rise. Implement city-wide urban canopy expansion

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Informal Settlement Residents	• **Structural** • Cleaning existing channels to manage immediate flood risks. • Installing guttering and tanks for rain harvesting to mitigate water scarcity. • **Non structural** • Using participatory GIS to document vulnerabilities and assets. • Educating residents on immediate evacuation procedures and health risks. • Nature based solutions • Tree planting (green cover): Planting for immediate shade and micro-climate cooling. • Community gardening: Establishing vertical or container gardens for food security and income.	• **Structural** • Improved sanitation infrastructure • Installing materials that allow water infiltration on pathways to reduce runoff. • **Non structural** • Developing micro-insurance schemes specifically for informal, low-income households. • Establishing community-based waste collection to prevent drain clogging. • **Nature based solutions** • Developing wastewater-treatment systems using plants to manage sanitation and flooding. • Biopores/Infiltration pits: Creating holes to improve soil water infiltration. • Green walls/facades: Utilizing climbing plants on buildings to reduce heat Absorption.	• **Structural** • Implementing comprehensive drainage systems to manage large-scale flooding. • Non structural • Updating urban planning regulations to recognize and support informal areas. • Training local leaders in climate adaptation, governance, and project management • Nature based solutions • Waterfront restoration: Replanting riparian vegetation to control erosion and floodwaters. • Urban reforestation: Establishing parks and green corridors to reduce urban heat island effects. • Restoring floodplains: Allowing natural water retention in designated green zones to buffer against major floods.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Vulnerable and Marginalized Groups	• **Structural** • Small-scale water harvesting. • Flood protection: Small-scale gabions, dikes, and drainage improvements in urban informal settlements (e.g., in Ikapoloko area) to reduce water-borne disease risk. • Reinforced housing. • **Non structural** • Climate Literacy: Training on climate change risks, disaster preparedness, and adaptation, including the use of art-based, visual methods for engagement. • Micro-insurance: Access to index-based insurance for farmers to cushion against drought-related losses. • **Nature based solutions** • Tree planting: Urban greening and reforestation for cooling and flood prevention. • Wetland/Riparian restoration: Clearing waste and planting vegetation along riverbanks to reduce flood risk. • Small-scale composting: Converting waste into fertilizer to improve soil fertility in community gardens.	• **Structural** • Resilient sanitation. • Drought-tolerant irrigation: Installation of drip irrigation systems for smallholder farmers. • **Non structural** • Livelihood diversification: Support for switching to drought-resistant crops, bee-keeping, or vocational training outside climate-sensitive sectors. • Gender-responsive planning: Ensuring women have a voice in local climate committees and budget allocations. • **Nature based solutions** • Agroforestry: Integrating trees into farming systems to improve soil health, water retention, and create shade.	• **Structural** • Upgrading roads, bridges, and hospitals to be climate-proof (e.g., elevated structures). • Resettlement: Moving communities away from high-risk flood plains. • **Non structural** • Policy integration: Mainstreaming climate risk into all local and national development plans. • Land tenure security: Securing land rights for marginalized groups to encourage long-term investment in land rehabilitation. • **Nature based solutions** • Large-scale protection of water catchment areas through reforestation.
Natural Assets			

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Urban Green Infrastructure	• **Structural** • Permeable Pavements: Replacing conventional asphalt with porous materials to increase infiltration. • Rain Gardens/Bioswales: Constructing small-scale, vegetated, depressed areas to capture and filter runoff from streets and roofs. • **Non structural** • Establishing a registry of existing green areas to monitor quality and quantity. • Urban Agriculture Initiatives: Promoting community gardens for food security and social cohesion. • "Green" Zoning Ordinances: Updating zoning laws to require a minimum percentage of permeable surfaces in new developments. • **Nature based solutions** • Urban Reforestation/Tree Planting: Increasing canopy cover to provide shade and reduce heat. • Conservation of Existing Green Spaces: Protecting mature parks and remnant habitats from urban sprawl. •	• **Structural** • Green Alleys and Parking Lots: Retrofitting paved surfaces with vegetation and infiltration systems. • Constructed Wetlands: Building artificial wetlands to manage storm water and improve water quality. • **Non structural** • Implementing monitoring systems for air quality, temperature, and water absorption to assess UGI impact. • Capacity Building and Education: Training local staff and educating residents on maintaining UGI to ensure long-term functionality. • Incentive Programs: Offering subsidies for private homeowners to install green roofs or cisterns. • **Nature based solutions** • Wetland and Riverine Restoration: Rehabilitating degraded water bodies to regulate flood shocks and improve water quality. • Native Species Planting: Selecting drought-resistant and native vegetation to minimize water use and maintenance Needs.	• **Structural** • Multi-functional Blue-Green Corridors: Creating interconnected networks of parks, rivers, and forests that span the city, reducing large-scale flooding. • Terracing and Slope Stabilization: Implementing nature-based solutions to reduce landslide risk in hilly terrain. • **Non structural** • Sponge City" Policies: Implementing comprehensive, city-wide strategies for water retention and reuse. • Spatial Justice Planning: Ensuring equitable distribution of green space across high- and low-income neighborhoods. • **Nature based solutions** • Ecological Connectivity Enhancement: Linking fragmented natural habitats to support biodiversity. •

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Urban Blue Infrastructure	• **Structural** • Cleaning and desilting canals and drainage channels to increase capacity; installing small-scale storm water retention ponds; repairing existing flood pumps and drainage tunnels. • **Non structural** • Implementing early warning systems for floods and heatwaves; establishing community-led cleanup initiatives; enforcing zoning regulations to prevent construction in floodplains. • **Nature based solutions** • Clearing debris from riverbanks and planting native vegetation; implementing temporary urban gardening in flood-prone areas.	• **Structural** • Developing "Sponge City" components like permeable pavements, rain gardens, and bioswales; building underground water storage tanks for rainwater harvesting. • **Non structural** • Integrating biodiversity and green infrastructure guidelines into city master plans; digitizing water systems for real-time monitoring; developing regulations for new developments. • **Nature based solutions** • Rehabilitating urban wetlands and riparian forests for natural filtration and storage; restoring riverbanks and establishing green corridors to connect habitats.	• Structural • Building 10-mile "Big U" type protective systems (combining berms, elevated parks, and floodwalls); creating large-scale, multifunctional water plazas that serve as recreational spaces during dry periods; expanding wastewater recycling infrastructure for water reuse. • Non structural • Mainstreaming climate adaptation into all municipal budgets and policies; implementing comprehensive "Urban Greening Plans" for cities with 20,000+ inhabitants; adopting "Nature Restoration Law" targets for urban biodiversity. • Nature based solutions • Transforming areas into natural water-retention parks.

Category	Recommended Solutions		
	Immediate	**Mid-term**	**Long-term**
Peri-urban and Agricultural Systems	• **Structural** • Installation of rainwater harvesting systems, small-scale drip irrigation, and rehabilitation of existing drainage channels to manage runoff. • **Non structural** • Distribution of drought-resistant/early-maturing crop varieties (e.g., cassava, sweet potatoes), training on composting and establishing emergency response protocols for flash floods. • **Nature based solutions** • Distribution of drought-resistant/early-maturing crop varieties (e.g., cassava, sweet potatoes), training on composting, and establishing emergency response protocols for flash floods.	• **Structural** • Construction of medium-sized composting systems, rehabilitation of contaminated ponds/lakes for aquaculture, and upgrading road access for flood resilience. • **Non-structural** • Development of municipal policies for safe wastewater reuse in agriculture, creating market platforms for local producers to reduce food miles, and implementing climate-smart agriculture training. • **Nature-Based solutions** • Promoting agroforestry on steep slopes to prevent flashfloods, creating riparian buffers along rivers for flood filtration, and restoring wetlands.	• **Structural** • Implementing large-scale wastewater treatment and reuse systems, designing "green mosaics" (integrated land-use planning), and building flood-resilient infrastructure in hazard zones. • **Non-structural** • Mainstreaming peri-urban agriculture into urban master plans, establishing permanent legal protection for agricultural land against urban sprawl, and creating comprehensive climate insurance schemes. • **Nature-Based solutions** • Large-scale watershed management, restoring degraded ecosystems to provide natural buffers, and developing "productive parks" that combine agriculture, water storage, and Recreation.

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Annex 1. Historical Hazard Events

Hazard Event/Type	Flashfloods
Date or Period	8th September 2025
Location	Malaba central ward was mostly affected
Intensity	Flood depth of 4inches, duration was for 3 hours as the waters flowed to River Malakisi in Malaba Central ward.
Social Impacts	There were no fatalities, many households were affected but mostly the elderly living in semi-permanent structures
Physical Impacts	Perimeter walls collapsed in 3 areas, homes suffered water damage and transport was affected for a few hours as the roads Were impassable. To date, Ikapoloko route continues to suffer erosion when it rains and is now eating into the road.
Economic Impacts	Transport was affected for a few hours, Malaba primary school learning was affected as they had to rehabilitate the school compound
Ecological Impacts	Top soil was washed away. Solid waste was carried into the river leading to river water pollution, some trees were carried by the water

Annex 2. Data Sources

Page	Data	Data Source
6-8	Pluvial flooding, precipitation changes, extreme heat, temperature increase hazard levels (Current, 2050 SSP2-4.5, 2050 SSP5-8.5, 2100 SSP2-4.5, 2100 SSP5-8.5)	World Bank Climate Change Knowledge Portal
13	Malaba Municipality core population (2019 Census)	Kenya National Bureau of Statistics (KNBS), 2019 Kenya Population and Housing Census
13	Demographic indicators and projections (2019–2027)	KNBS Census 2019, County Population Projections
14	Geographic area (57.9 km²), coordinates, altitude	Survey of Kenya, County Spatial Plan
24	Hazard screening matrix	Kenya Meteorological Department (KMD) historical data, IPCC reports, local expert judgment
25	Climate indicators and thresholds for key hazards	World Bank Climate Change Knowledge Portal, KMD
26	Current and future hazard levels (temperature, precipitation, flooding, heat)	World Bank Climate Change Knowledge Portal, KMD downscaled projections
28-30	Urban elements inventory (infrastructure, populations, natural assets)	Municipal departments, GIS mapping, field surveys, KNBS data
32-62	Exposure, vulnerability, and impact assessments for each hazard across urban elements	Municipal sector reports, community consultations, field assessments, KMD data
64-67	Climate risk matrices for pluvial flooding, precipitation changes, extreme heat, temperature increase	Integration of hazard data (World Bank/KMD) with exposure/vulnerability assessments
70-83	Climate adaptation and resilience solutions	Best practices from IPCC, UNDP, NEMA, and municipal technical workshops