

REPUBLIC OF KENYA

GOVERNMENT OF MAKUENI COUNTY



## EMALI-SULTAN HAMUD MUNICIPALITY

# URBAN CLIMATE RISK PROFILE

# 2026



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The preparation of this Climate Risk Profile was undertaken through a collaborative effort by Raivy Company Limited consultancy services with key technical officers from the municipality who provided sectoral expertise and guidance throughout the process.

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# FOREWORD

Climate change is no longer a distant environmental concern; it is a defining development challenge of our time. Across Kenya, and particularly within Emali-Sultan Hamud Municipality, the impacts of rising temperatures, erratic rainfall patterns, prolonged droughts, flash floods and land degradation are increasingly evident. These changes are affecting livelihoods, straining infrastructure, threatening food security, and placing our most vulnerable populations at heightened risk.

This Urban Climate Risk Profile provides a comprehensive assessment of the municipality's exposure, sensitivity, and adaptive capacity to key climate hazards including heat stress, extreme precipitation, pluvial flooding, prolonged dry spells, and gully erosion. By combining scientific climate projections with local knowledge and sectoral analysis, this document offers an evidence-based foundation for informed decision-making. It identifies climate risk hotspots, highlights vulnerable populations and systems, and outlines practical adaptation and mitigation strategies tailored to our unique urban and peri-urban context.

The findings underscore an important reality: while infrastructure systems face varying levels of risk; our populations, particularly informal settlement residents, low-income households, women, children, the elderly, and persons with disabilities bear the greatest vulnerability. At the same time, our agricultural systems and natural assets remain highly exposed to drought, flooding, and land degradation. These insights compel us to integrate climate resilience into municipal planning, infrastructure development, service delivery, and investment prioritization.

This Risk Profile aligns with national and county climate policy frameworks and supports the mainstreaming of climate action into municipal development planning. It is intended to guide the Municipal Board, County Departments, Ward Climate Change Planning Committees, development partners, civil society organizations, and the private sector in implementing coordinated and locally led climate action.

The Municipal Board commends the technical team and stakeholders who contributed to the preparation of this document. Their dedication reflects our shared commitment to proactive planning, inclusive governance, and sustainable urban development.

As we move forward, let this Urban Climate Risk Profile serve not merely as a report, but as a living guide; informing policy, shaping investments, and strengthening partnerships. Together, we can transform climate risks into opportunities for innovation, resilience, and inclusive growth.

Let us act decisively today to build a safer, stronger, and climate-resilient Emali-Sultan Hamud for present and future generations.



**Anderson Matheka**

**Municipal Board Chairperson**  
**Emali – Sultan Hamud Municipality**

## **ACKNOWLEDGEMENT**

The preparation of the Urban Climate Risk Profile for Emali–Sultan Hamud Municipality would not have been possible without the collective effort, dedication and support of numerous individuals and institutions.

I sincerely acknowledge the leadership and guidance of the Government of Makueni County for providing the enabling policy and institutional framework that facilitated the development of this Risk Profile. Special appreciation goes to the Municipal Board for their commitment to strengthening climate resilience within the municipality.

I extend my profound gratitude to the technical team whose input, data provision and field insights were invaluable to this assessment.

Finally, I appreciate all stakeholders who contributed directly or indirectly to the successful completion of this document. Your commitment demonstrates a shared resolve to build a climate-resilient, sustainable and prosperous Emali–Sultan Hamud Municipality for present and future generations.



**Philip Ngila**

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## List of Acronyms

ASALs	Arid and Semi-Arid Lands
CCAP	Climate Change Action Plan
CA	Conservation Agriculture
CCF	County Climate Change Fund
CCU	Climate Change Unit
CIDP	County Integrated Development Plan
CRA	Climate Risk Assessment
CSO	Civil Society Organizations
FLLoCA	Financing Locally Led Climate Action
GBV	Gender-based Violence
GDP	Gross Domestic Product
GHG	Green House Gases
GOMC	Government of Makueni County
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
KMD	Kenya Meteorological Department
M&E	Monitoring and Evaluation
NCCC	National Climate Change Council
NGOs	Non-Governmental Organizations
OVC	Orphans and Vulnerable Children
PCRA	Participatory Climate Risk Assessment
PWD	Persons with Disability
RCRA	Rapid Climate Risk Assessment
SEKEB	South Eastern Kenya Bloc
SSP	Shared Socioeconomic Pathways
UNFCCC	United Nations Framework Convention on Climate Change
WCCPC	Ward Climate Change Planning Committee

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## Executive Summary

Across the world, climate change has shifted the landscape of risk for communities, especially those living in urban areas. For municipal leaders, the best way to respond to this challenge is to understand the risks that their communities face. This risk-assessment process can help a community understand the resources it will need to invest in and how it might prioritize strategies to reduce risk. Informed and prepared communities will be more resilient to risks and will bounce back more quickly than those that are unprepared and uninformed.

Climate change poses a significant threat not only to Emali - Sultan Hamud Municipality but to the wider Makueni County, with rising temperatures, unpredictable rainfall and extreme weather events increasingly impacting livelihoods and human wellbeing. Key drivers include deforestation, poor waste management, and unsustainable fossil fuel use, among others. The impacts are already evident in the form of frequent flooding in parts of the municipality, declining farm yields, declining livestock numbers, destruction of infrastructure and general loss of livelihoods and rising poverty. There is also an unprecedented rise in diseases like diarrhea, malaria and soil helminth cases, among many other diseases.

Climate mitigation and adaptation are essential for safeguarding community livelihoods as well as ecosystems against the vagaries of climate variability. Yet building resilience requires proactive mitigative and adaptive measures, including climate smart agriculture to secure food production, improving water management, and strengthening healthcare systems to respond to emerging and re-emerging diseases spawned by climate change. At the same time, there is need to invest in climate-resilient infrastructure that can withstand the test of floods and storms, while also adopting sustainable energy alternatives like to help reduce vulnerability and protect livelihoods.

Integrating climate adaptation into planning, policies and community initiatives within Emali - Sultan Hamud Municipality can help reduce climate risks, protect people and create pathways for a more resilient and prosperous future. It is for this reason that this Risk Profile analyses the climatic conditions within the municipality, both past and present, and leverages projected future scenarios in order to foreground present and future climate action necessary to help plan, develop and deliver a more resilient, sustainable and equitable Emali - Sultan Hamud Municipality moving into the future.

The main objective of this Climate Risk Profile was to assess the municipality's exposure, sensitivity and adaptive capacity to climate-related hazards in order to inform evidence-based planning, decision-making and investment towards building municipal climate resilience. The profile sought to generate localized climate risk information that integrates environmental, social and economic dimensions to guide sustainable urban development, reduce vulnerability, enhance the community's preparedness and adaptive capacity to climate change impacts.

The specific objectives are to: -

- i. Identify and characterize key climate hazards affecting Emali - Sultan Hamud Municipality.
- ii. Analyze the exposure and sensitivity of critical sectors and systems.
- iii. Assess the municipality's adaptive capacity at institutional, community, and household levels, highlighting existing coping mechanisms, governance structures, and resource constraints.
- iv. Map climate vulnerability hotspots within Emali - Sultan Hamud Municipality.

- v. Recommend priority adaptation and mitigation measures to support integration of climate resilience into Municipal planning and development initiatives.

The key hazards identified during the analysis include the following:

1. Hydro-metrological hazards - Pluvial flooding, flash floods, riverine
2. Geo-hazards - Gully erosion, Earth Tremors, Mudslides/Land slides
3. Climatological hazards – Urban droughts, Heat stress (Extreme heat, Cold stress)

Risk results summary for each key hazard is presented below.

### **Drought**

- Infrastructure & Services: *Very low risk*. Droughts mainly stress water supply and agriculture; they rarely damage physical systems. There is *insignificant* impacts and *Low* risk for drainage, wastewater, waste and transport under drought. This matches evidence that urban drought causes widespread water scarcity but not structural failure.
- Populations: *Very high risk*. Urban and informal communities are severely affected by drought. Informal settlements face *catastrophic* impact (high risk), and urban poor suffer *major* impact, due to water shortages and heat exposure. Drought in rural areas also disrupts food supplies, worsening urban food insecurity. Vulnerable groups (elderly, slum residents) have little resilience to heat and lack access to reliable water, consistent with studies that drought-induced food/water crises hit the poorest hardest.
- Natural Assets: *Critical risk*. Peri-urban agriculture is *catastrophic* impact (very high risk); prolonged dry spells can wipe out crops and reduce food supply. Urban green infrastructure is *major* impact (medium risk); parklands and trees suffer water stress. This aligns with findings that drought causes “widespread disruptions... including ecosystems [and] peri-urban agriculture”. By contrast, blue (water) infrastructure sees moderate risk since reservoirs and canals simply hold less water.

### **Floods**

- Infrastructure & Services: *Severe risk*. There are catastrophic impacts and Very High risk for stormwater drainage, water/wastewater and transport during floods. Flood waters inundate sewers and roads, damaging infrastructure and causing unsafe conditions. This is supported by studies noting floods “cause damage to infrastructure and unsafe living conditions” with large economic losses. Even energy and emergency services face elevated (Medium) risk from storm-related outages.
- Populations: *High risk*. Informal settlement residents and marginalized groups have *Major–Catastrophic* impact (High risk) from flooding, as these communities are often in low-lying or poorly drained areas. Urban residents overall show lower risk (Medium) – reflecting that not all neighborhoods flood but low-income urban zones bear the brunt. Indeed, projections indicate low-GDP areas and informal urban communities will see disproportionate increases in flood exposure by 2100. Flood events “regularly disrupt livelihoods” for the urban poor, underscoring this vulnerability.
- Natural Assets: *Mixed risk*. Urban green spaces and waterways are relatively resilient to temporary inundation (both show Low risk). However, peri-urban agricultural land is at

*High risk*: floodwaters can destroy crops and soil fertility. Note that floodplains can replenish some ecosystems, but rapid urban expansion has eliminated natural buffers. (In fact, increasing impervious surfaces is a key driver: every 1% rise in sealed area can boost urban flood risk by ~10%.)

## Extreme Rainfall

- Infrastructure & Services: *Critical risk*. Intense storms (flash floods) catastrophically affect stormwater and drainage (Very High risk) and heavily impact transport. There is catastrophic impacts on stormwater drainage and *very high risk* reflecting overwhelming of drainage systems. Research confirms that climate change is intensifying extreme rainfall, undermining urban drainage designs. In one study, 24-hour rainfall for rare storms is projected to rise ~32% by mid-century, markedly escalating flood risk.
- Populations: *High risk*. Urban and informal communities again face *major* impacts (High risk) from flash floods. Short-duration downpours can flood streets and homes, threatening life and property. The risk profile shows both urban residents and informal settlers at high risk under extreme rain. Vulnerable groups likewise remain at high risk. This matches trends: extreme precipitation events are rising in frequency and disproportionately affect poorer neighborhoods with inadequate stormwater infrastructure.
- Natural Assets: *High risk*. Peri-urban agriculture is vulnerable to sudden inundation (High risk). Urban green/blue areas offer some stormwater retention and thus show lower risk (rainfall helps water bodies), but engineered or paved areas exacerbate runoff.

## Heat Stress

- Infrastructure & Services: *Moderate risk*. Most built infrastructure (roads, energy, waste) shows low sensitivity to heat alone. The exception is Water & Wastewater Management, which is *catastrophic* impact (High risk): higher demand and water shortages can overwhelm supply and sanitation systems. This aligns with projections that rising heat will sharply increase urban water scarcity.
- Populations: *Very high risk*. All urban population categories are at least *major* impact (High risk) from heat. Heatwaves directly affect health (heat stress, dehydration) and livelihoods (labor productivity). There is an indicating of *High risk* for urban, informal and marginalized groups. Vulnerable communities (low-income, slum dwellers, elderly) suffer most: they have limited cooling, poorer housing, and often lack water. Extreme heat already compromises well-being in cities, and small-scale farmers and low-income urban households are hardest hit by rising temperatures. Higher heat also slows agriculture, threatening food supply.
- Natural Assets: *Severe risk*. Peri-urban agricultural systems are *catastrophic* impact (Very high risk) under heat, as crop yields plummet in drought/heat. Urban green spaces have *Major* impact (Medium risk): heat stresses trees/parks unless irrigated. Thus, heat exacerbates the stress on food systems, matching findings that “increased temperatures have slowed agricultural productivity”.

## Storms and High Winds

- Infrastructure & Services: *High risk*. Storms produce *major* impacts to stormwater systems, water supply, and transport. High winds and torrential rain can overwhelm drainage and break roads and bridges. While energy infrastructure is rated low risk here, in practice strong storms can cause outages. The overall pattern mirrors hurricane impacts: storms “rip apart homes, flood streets, knock out power”.
- Populations: *Moderate risk*. Urban and informal populations show *Minor–Moderate* impacts (Medium risk) in the tables. Direct storm injury and displacement are less frequent than with floods or heat, but indirect effects (flooding, loss of services) still threaten these groups. Vulnerable and marginalized communities bear *Major* risk: lacking robust housing and resources, they are more exposed to storm damage.
- Natural Assets: *High risk*. Peri-urban agriculture again faces severe impacts from storms (High risk), as heavy rains and winds destroy crops. Urban green infrastructure (parks, trees) mostly shows low risk, although vegetation can be damaged and soil eroded.

Across all climate hazards, low-income and informal settlements face the most severe risks. Urban areas in the developing world are experiencing growing vulnerability to heatwaves, droughts, floods and storms, and this trend is projected to continue. Infrastructure and services (storm drainage, water/waste systems, energy) generally show low risk under drought and heat but very high risk under flood and storm scenarios (floods damage infrastructure, storms knock out power and transport). By contrast, populations and agriculture consistently suffer high to catastrophic impact: Table 17, 18, 19, 20 and 21 show *urban residents*, *informal settlers*, and *vulnerable groups* with high risk in nearly every hazard, while *peri-urban agriculture* faces catastrophic risk under drought, heavy rain, heat and storms. This aligns with findings that climate extremes (e.g. heatwaves, floods) are already undermining food and water security, especially for the poorest communities. Critically, risk levels remain high through mid-century and 2100 in both moderate and high emissions scenarios, indicating persistent vulnerability. The IPCC emphasizes that rapid urban growth in low-resource cities especially unplanned/peri-urban development is a major driver of this risk.

### Priority recommendations:

- Invest in resilient infrastructure and natural buffers: reinforce drainage and flood defenses in high-risk areas, secure water supply against drought, and preserve green/blue infrastructure (parks, wetlands) to absorb floods and heat.
- Special focus is needed on informal settlements and marginalized populations through inclusive adaptation planning such as promotion of climate-resilient farming practices, and promotion of climate insurance to cushion farmers from climate-induced losses would take precedence, provision of certified seeds and other farm inputs attuned to climate change, early warning systems, and improved basic services.

# 1. Context

## 1.1. Situating Climate Change in National Development

Climate change is no longer a distant threat. Across the globe, communities are grappling with challenges occasioned by a changing climate. These climate-induced challenges are often aggravated by other underlying structural factors such as poverty, minimal technological advancement and uptake, lack of capital, inequitable land distribution, under-developed public infrastructure and over-reliance on rain-fed agriculture. While climate change is happening globally, its specific impacts are often felt differently at the local level, with some areas more disproportionately hit compared to others. As a result, initiatives geared towards mitigating and adapting to climate change are being implemented at different spatial scales in order to deliver the best set of climate action.

In Kenya, climate change has a significant socio-economic impact, costing the country up to 2.8% of its annual gross domestic product (GDP). Recent Intergovernmental Panel on Climate Change (IPCC)'s vulnerability assessment indicates that more than 85% of Kenya's land mass is extremely susceptible to climate change impacts. As a country, our vulnerability is especially driven by the fact that the economy is largely dependent on climate-sensitive sectors such as agriculture, tourism and energy, yet our low-income status impedes our ability to adequately tackle associated impacts of climate change.

As a national strategic priority, Kenya has ratified the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the East African Community (EAC) Climate Change Policy Master Plan and Strategy (2011–2013). Environmental protection is a national priority as outlined in the Vision 2030. Kenya has also established a National Climate Change Response Strategy (NCCRS), a National Climate Change Action Plan (NCCAP) and the Climate Change Act of 2016. The Climate Change Act outlines a regulatory framework for a more effective action on climate change, to enhance resilience and advocate for low carbon emissions. The Act also promotes the mainstreaming of climate change responses in the design, planning and implementation for budgeting of Kenya's sustainable development. The country has also developed Nationally Determined Contributions (NDC), whose purpose is to set targets for reducing greenhouse gas emissions in line with the UNFCCC Conference of Parties (COP).

## 1.2. Which Way Development? Mitigation vs. Adaptation

Climate observation data point to climate changes already occurring in a warming world, and predict more dramatic climate changes further into the future. As of today, more than 2.5 billion people face food security issues. And since 2008, 21.5 million people have become climate refugees on average each year. Adapting to climate change, particularly extreme weather, is one of the main ways to reduce risk and make communities more resilient and sustainable in the coming decades.

Adaptation actions aim to help existing communities and ecosystems become resilient to climate change and reduce the vulnerability of natural and human systems. Climate change adaptation can take the form of changes in the processes, practices or structures that limit damages or create benefits from the changing climate. Adaptation can minimize the present adverse effects and prevent future risks. This entails adjusting human systems to cope, as well as building resilience to

actual or anticipated climate change effects to reduce harm to populations or take advantage of the benefits it presents.

Climate mitigation on the other hand focuses on slowing the pace and direction of climate change, principally by reducing emissions of heat trapping greenhouse gases (GHGs). Communities that depend on extractive livelihood systems for example, have devised ways to adapt to climate change and variability in their local settings. However, the current speed at which climate change is taking place will modify known variability and resilience patterns in a way that communities are often less equipped to handle.

In developing countries such as Kenya, climate change impacts are more severe due to inadequate institutional and economic capacity of local communities to cope and adapt. Therefore, adaptation options ought to be formulated at community level so as to address low adaptation challenges.

### **1.3. Rationale for the Emali - Sultan Hamud Municipality Climate Risk Profile**

Urban areas today face unprecedented and uncertain risks associated with climate change. Thus, risk assessment is particularly relevant for municipalities because they are becoming increasingly vulnerable to severe events. The rising global population and massive migration to urban areas tends to concentrate people in ecologically fragile areas, which are particularly prone to the risk of natural disasters linked to climate change. Furthermore, many of the new urban dwellers have little by way of financial means to recover from a disaster. As urbanizing trends increase, so too will the importance of risk assessment and resilience planning for urban areas.

Across the world, climate change has shifted the landscape of risk for communities. For municipal leaders, the best way to respond to this challenge is to understand the risks that their communities face. This risk-assessment process can help a community understand the resources it will need to invest in and how it might prioritize strategies to reduce the risk. As can be reasonably expected, informed and prepared communities will be more resilient to risks and will bounce back more quickly compared to those that are unprepared and uninformed.

The risk-assessment process begins with a Risk Profile. Such a profile is developed by identifying the types of events that could occur in the municipality, the probability that events of varying severity will occur, and the consequences of those events, including economic, infrastructure, socio-cultural, and public health losses. Total risk is calculated by summing the values of risk associated with individual events. In general, taking action to minimize damage caused by extreme weather events is the best way to reduce exposure because the probability of a natural disaster occurring is beyond the community's control.

A comprehensive risk assessment is helpful in facilitating a variety of planning and policy-making interventions. At the very least, this Risk Profile will aid Emali - Sultan Hamud Municipality in assessing which wards are most and least exposed to a variety of climate change-related risks, enabling the leadership to direct growth and investment accordingly. In the same vein, evidence-based long-term plans will more precisely reflect anticipated impacts from droughts, floods, extreme heat, storms and other hazards likely impact Sultan-Hamud's development into the future.

## **Objective of the Climate Risk Profile**

The main objective of this Climate Risk Profile is to assess the municipality's exposure, sensitivity and adaptive capacity to climate-related hazards in order to inform evidence-based planning, decision-making and investment towards building municipal climate resilience. The profile aims to generate localized climate risk information that integrates environmental, social and economic dimensions to guide sustainable urban development, reduce vulnerability, enhance the community's preparedness and adaptive capacity to climate change impacts.

The specific objectives are to: -

- i. Identify and characterize key climate hazards affecting Emali - Sultan Hamud Municipality.
- ii. Analyze the exposure and sensitivity of critical sectors and systems.
- iii. Assess the municipality's adaptive capacity at institutional, community, and household levels, highlighting existing coping mechanisms, governance structures, and resource constraints.
- iv. Map climate vulnerability hotspots within Emali - Sultan Hamud Municipality.
- v. Recommend priority adaptation and mitigation measures to support integration of climate resilience into Municipal planning and development initiatives.

## **1.4. Urban Context**

### **1.4.1. Geographic location**

The Emali-Sultan Hamud Municipality was established through Emali-Sultan Hamud Municipal Charter in December 2022. The municipality covers an approximate area of 729km<sup>2</sup> (Figure 1). It partially covers three sub-counties, with Kilome accounting for 47%, Kibwezi West (33%) and Makueni (20%). With respect to wards, the Emali-Sultan Hamud Municipality covers the entire Kasikeu, Emali-Mulala and Mbitini wards and partially Nguu-Masumba Ward (88.52km<sup>2</sup>) and Nzaui-Kilili-Kalamba wards.

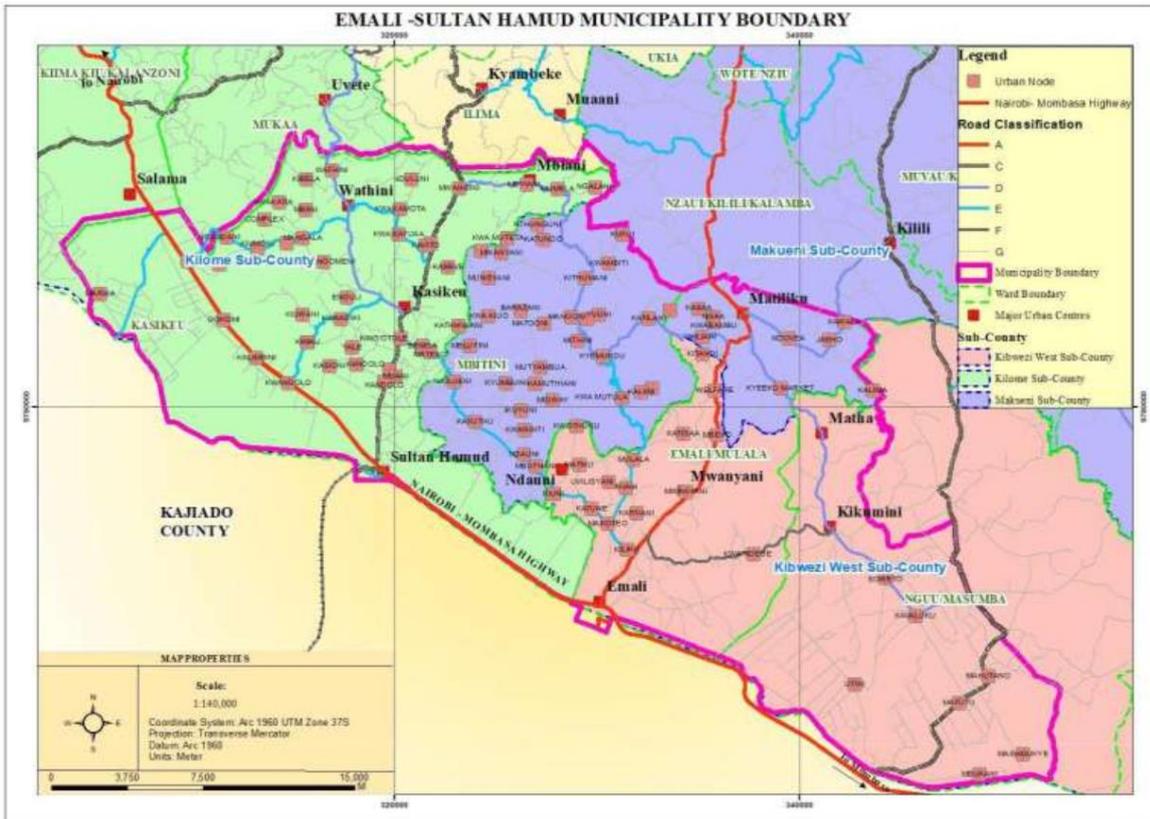


Figure 1: Emali-Sultan Hamud municipal boundaries

In terms of location, the municipality lies along the A109, that is, the Nairobi-Mombasa Highway, partially covering Kilome, Kibwezi and Makueni sub-counties. The A109 is a primary distributor connecting Nairobi, Kenya’s capital and largest city and Mombasa, the country’s largest port city. It also plays a regional role of connecting the country to the wider East African Region. More than 50% of all goods traded in the East African Community are moved through this major road that traverses Emali-Sultan Hamud Municipality and this has been identified as one of the key influencing factors to the economic growth of the municipality.

The municipality also connects to Tanzania through the Emali-Loitoktok Road. The Standard Gauge Railway also plays a key role in the growth and development of the municipality, especially from the influence of the Emali SGR station (Figure 2). Therefore, municipality is strategically located and if well planned it could contribute greatly to the economic growth of the region and the country at large.



Figure 2: Emali SGR station

Regionally, the municipality connects to Machakos County via the Nairobi-Mombasa Highway (A8) and A3 (Kithimani–Makutano–Wamunyu–Itangini– Ukia–Emali–IBD–Loitokitok, and to Kitui County via the Nairobi–Mombasa Highway through Emali to Kibwezi and Kibwezi–Kitui Road (Figure 3). In the Makueni County spatial planning context, the municipality is designated as an industrial zone.<sup>1</sup>

Administratively, the municipality covers parts of three sub-counties: Kilome, Makueni, and Kibwezi West. Kilome Sub-county contributes the highest percentage of the municipality’s coverage at 47%, followed by Kibwezi West at 33%, with Makueni being the least at 20% (Table 1 and Figure 4). As for the wards, the municipality covers the entire Kasikeu, Emali-Mulala, and Mbitini Wards, and partially Nguu-Masumba (88.52km<sup>2</sup>) and Nzaui-Kilili-Kalamba wards (Figure 5).

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<sup>1</sup> Government of Makueni County (2019) *Makueni County Spatial Plan (2019–2029)*. Wote: GMC.

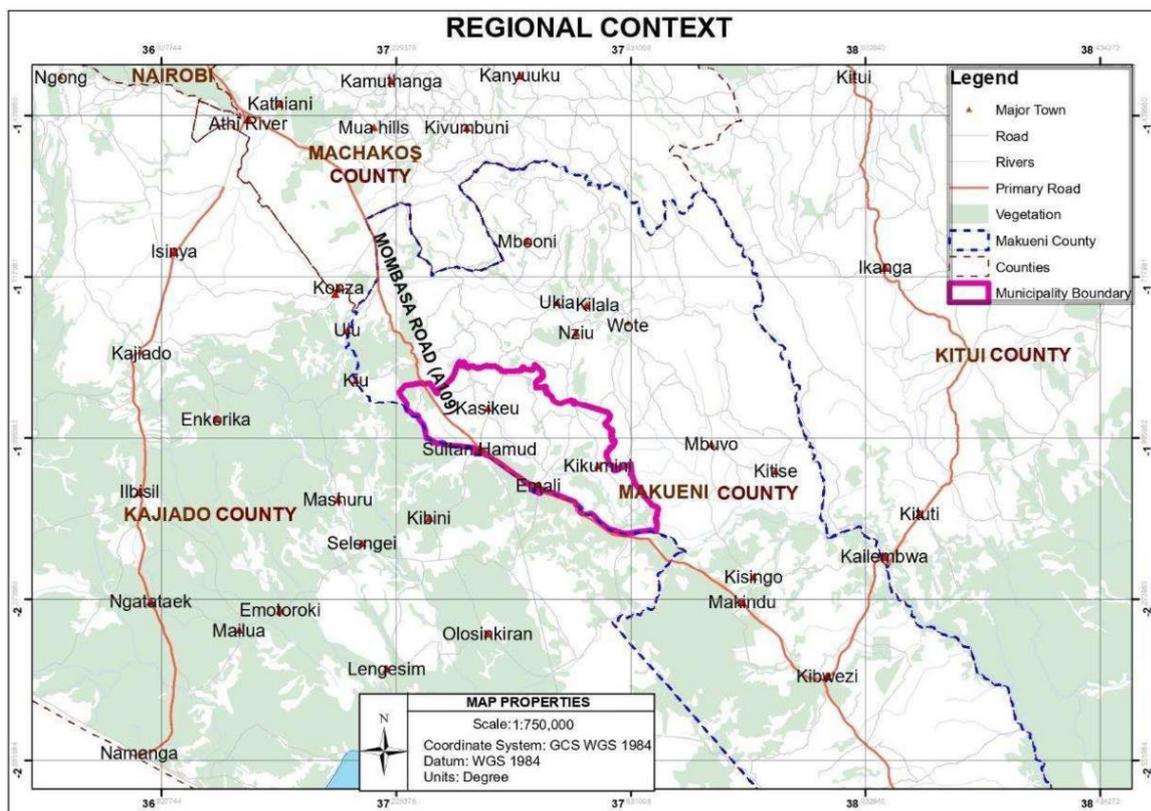


Figure 3: Regional context

Table 1: Area coverage by sub-counties

Sub-county	Total area	Area coverage contributing to the municipality (km <sup>2</sup> )	% coverage of municipality within sub-county
Kilome Sub-county	803.785	273.72	47
Makueni Sub-county	1543.492	115.04	20
Kibwezi West Sub-county	1715.28	88.52	33
<b>Total</b>		<b>577.00</b>	

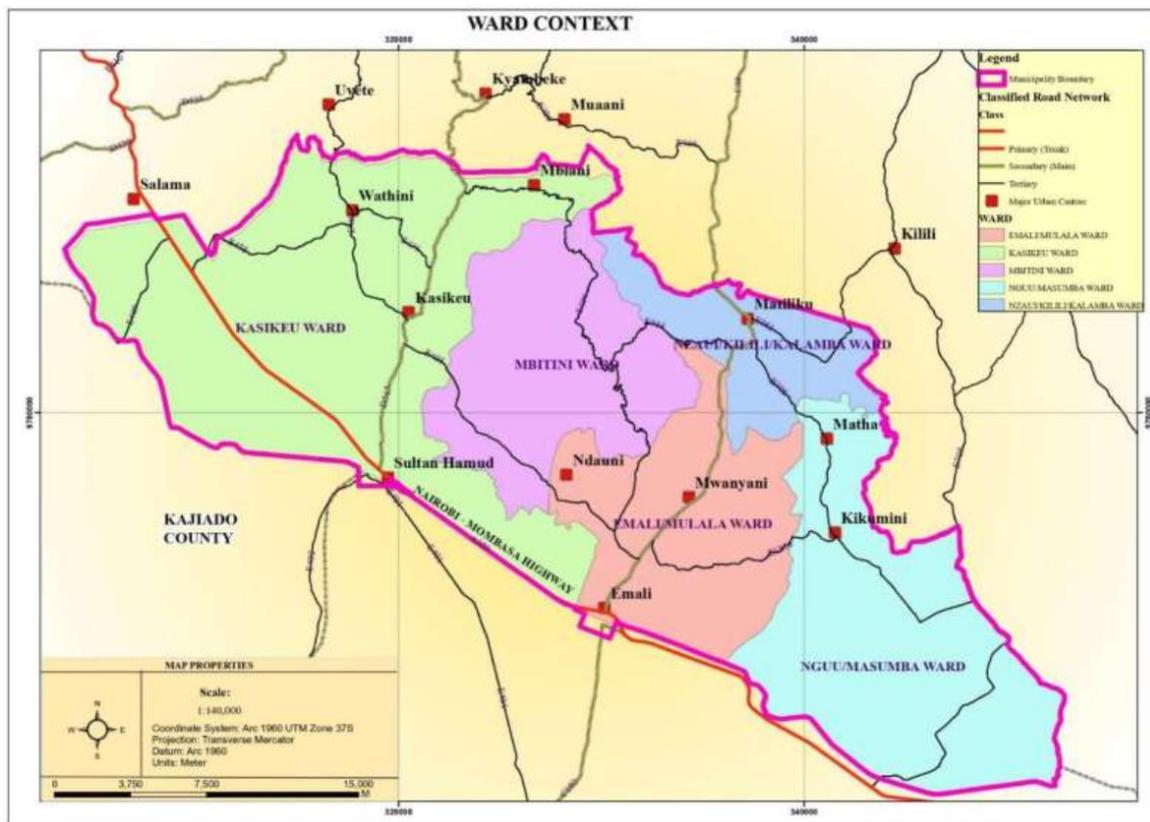


Figure 4: Ward context

#### 1.4.2. Governance structure

The municipality of Emali-Sultan Hamud was established through the Emali-Sultan Hamud Municipal Charter, as approved by the County Assembly in November 2022 and assented to by the Governor of the Government of Makueni County in December 2022. In accordance with the Charter, the Municipal Board is obliged to carry out a number of functions that include formulating and implementing various development plans within the municipality.

The Charter expressly spells out the following as objectives of the Municipality:

- i. To provide for efficient and accountable management of the affairs of the Municipality
- ii. To provide for a governance mechanism that will enable the inhabitants of the Municipality to participate in determining the social services and regulatory framework which will best satisfy their needs and expectations
- iii. To vigorously pursue the developmental opportunities which are available in the Municipality and to institute such measures as are necessary for achieving public order and the provisions of civic amenities, to enhance the quality of life of the inhabitants of the Municipality
- iv. To cost-effectively provide a high standard of social services to the inhabitants of the Municipality.
- v. To promote social cohesiveness and a sense of civic duty and responsibility among the inhabitants and stakeholders in the Municipality to facilitate collective action and commitment towards achieving the goal of a harmonious and stable community.
- vi. To provide services on all matters for the Municipality's benefits.
- vii. To foster the economic, social and environmental well-being of its community.

The institutional framework for the implementation of municipal functions is anchored on the structure as stipulated in the County Governments Act, 2012 (amended, 2020) and Urban Areas and Cities (Amendment) Act 2019. The framework provides a link with the County Executive for purposes of implementing municipal functions as contained in the municipal charter. The Municipality’s specialized directorates work with other departments of the County Government for the successful implementation of development plans and other routine operations. Figure 3 shows the municipal institutional structure as contained in the current Emali - Sultan Hamud Municipality Integrated Development Plan.

**Figure 16: Emali / Sultan Organizational Structure**



Figure 5: Institutional structure for Emali - Sultan Hamud Municipality

**1.4.3. Socio-demographic profile**

Makueni County has an urban population of around 11.8%, as significant levels of rural-urban migration have elevated this percentage, especially in the urban centres of Wote, Emali, Mito Andei and Kibwezi. The population density of the County is 82 inhabitants per km<sup>2</sup>, making it the

29<sup>th</sup> densest county among Kenya’s 47 counties. The annual population growth rate of Makueni County is estimated to be 1.3%, including an urbanisation rate of 2%, which means urban populations within the county are growing faster than the population as a whole. If this growth rate continues it is projected that by 2030 the population of the County will reach 1,139,452 inhabitants. However, it is important to note that these projections rely on observed growth rates, but do not take account of other factors likely to impact growth — including fertility rates, land availability, infrastructure and job opportunities. What's more, these projected growth rates do not account for the likely implications the Konza Technopolis will have on migration into Makueni County, as more people get attracted by the employment opportunities and facilities the technopolis is likely to deliver. This will require a detailed approach to planning and social development designed to mitigate against potential threats to the County’s development prospects.

Emali-Sultan Hamud Municipality partially covers three sub-counties where Kilome accounts for 47%, Kibwezi West (33%) and Makueni (20%). With respect to wards, the municipality covers the entire Kasikeu, Mbitini and Emali/Mulala wards and sections of Nguu/Masumba and Nzaui-Kilili-Kalamba wards, and is defined to include the sub-locations therein. The municipality covers approximately 729km<sup>2</sup>, with a total population of 113,000 persons.

The municipality has two major towns namely Emali and Sultan Hamud. The urban population of these towns as per the Kenya National Bureau of Statistics, 2019 is shown below.

**Table 2: Population distribution by major urban centers**

Urban Area	Census (2019)		
	Male	Female	Total
<b>Emali</b>	4,806	5,016	9,822
<b>Sultan-Hamud</b>	3,135	2,733	5,868
<b>Kasikeu</b>	2,206	2,153	4,359
<b>Matiliku</b>	1,865	1,734	3,599

*Sources: Municipal Integrated Development (2021-2030), KNBS 2019*

Based on the county’s population growth rate of 1.4%, the municipality’s population is projected to reach approximately 128,648 persons by the year 2030. This projection underscores the need to plan for adequate infrastructure and services, which will be crucial in fostering the municipality’s growth, especially given the anticipated increase in human capital. The table below shows the municipality’s projected population.

**Table 3: Projected population by ward**

Ward	Total Population 2019	Projected Population (2027)	Projected Population (2030)
Kasikeu Ward	35621	38,186	40,553
Mbitini Ward	24958	26,755	28,414

Emali/Mulala Ward	28528	30,582	32,478
Nzaui Kilili Kalamba Ward	8135	8,721	9,261
Nguu/Masumba Ward	15,759	16,894	17,941
<b>Total</b>	<b>113,001</b>	<b>121,137</b>	<b>128,648</b>

*Sources: Municipal Integrated Development (2021-2030), KNBS 2019*

#### 1.4.4. Economic context

Agriculture remains the main economic mainstay across Makueni County, contributing 78% to the total county GDP despite the fact that only 17% (888km<sup>2</sup>) of the county is currently under cultivation. The average farm size in the county is 1.2 Ha for small farmers and 12Ha for large-scale farmers. The middle zone of the county, where the Emali-Sultan Hamud Municipality lies, is characterized by the production of green grams, pigeon peas, hay, cow peas, mangoes, citrus fruits, paw paws, melons, cotton and sisal. An estimated 26.2% of the employed labor force is primarily engaged in small-scale agriculture and pastoral activities. The main challenges that this sector faces are inadequate value-addition by agro-processing industries which can be attributed to inadequate investment in the sector by the County Government and other stakeholders. Other challenges facing agricultural productivity include low adoption of appropriate technologies, high cost of inputs and services, underdeveloped irrigation infrastructure and inappropriate land use practices. Besides, climate change remains a major threat to this sector.

Apart from agricultural livelihoods, there are several commercial enterprises in the municipality among them retail and wholesale, petrol service stations, bars, butcheries and bakeries. Others include small-scale eateries, particularly those that span the length of the Nairobi-Mombasa Highway, and an assortment of other business enterprises. Retail shops, bars and hotels form the bulk of business ventures. Recently, the municipality has attracted major supermarkets chains in the country such as Mulley's and other self-selection outlets, which have opened their branches around the central business area of Emali Town (Figure 6). Other commercial activities include sand mining which takes place along Muoni River as well as small-scale quarrying.



Figure 6: Emali modern market

Most of the commercial activities are mainly concentrated at Emali and Sultan Hamud towns and other urban centres within the municipality. Emali Town being the core business and administrative centre has the bulk of the commercial activities within the municipality. The commercial activities fall into both formal and informal categories. Formal commercial activities include banking services, transport business, SACCOs, wholesale businesses, general shops, open-air markets, hotels and restaurants, among others. Besides, these informal activities such as street vending, small shops, and food stalls are prevalent and remain vital for the local economy as they provide jobs and meet community needs. The Nairobi-Mombasa Highway plays a crucial role in supporting trade and economic activity, with thriving businesses outlets along its route. Traders have established *vibandas* along the highway, boosting the local economy but facing risks such as traffic accidents due to their roadside location. These *vibandas* have also sparked land use related conflicts as their commercial use clashes with formally zoned trading areas.

#### 1.4.5. Land use context

The morphology of Emali - Sultan Hamud Municipality is largely in keeping with the wider Makueni County as a whole: largely rural in character, with land mostly used for agricultural activities, the backbone of the local economy.

The primary settlement pattern observed within the municipality is a linear development pattern along the major roads, mainly characterized by commercial activities. This pattern is exemplified by the experiences in Emali and Sultan-Hamud towns, which stand as the major hubs in the municipality and have evolved into the primary commercial centers for Kibwezi West and Kilome sub-counties, respectively. Their strategic positioning along the Nairobi-Mombasa highway has propelled their simultaneous growth, marked by an accelerated rate of development and population expansion since the 2000s. Several factors have contributed to the growth of these towns, including:

- Presence of institutions such as schools, sub-county administrative offices, sub-county hospitals, and police stations.

- Availability of a standard gauge railway station in Emali Town.
- Serving as stop-overs for long-haul buses, heavy trucks and lorries plying the Nairobi-Mombasa-Kampala route.

Generally, the municipality is characterized by multiple urban centers that have significantly influenced the development of broad land use zones. These existing urban centers and developments are integral to the municipality's spatial development framework, serving as essential building blocks for its growth and organization. They act as hubs for economic, social, and cultural activities, shaping the municipality's overall vitality and character. The arrangement of residential, commercial, industrial, and recreational zones is influenced by these centers, influencing the current land use patterns. They also play a crucial role in shaping the municipality's transportation infrastructure, with well-developed roads and public transit systems strategically connected to serve them. Preserving historically and culturally significant urban centers is essential for maintaining the municipality's heritage while at the same time embracing modern development.

Zoning regulations and urban planning guidelines are shaped by these centers to maintain their character or promote specific land uses. The attractiveness of these centers affects investment and development decisions, fostering further growth in surrounding areas. Integrating these centers into the spatial development framework enables efficient use of existing resources and infrastructure, promoting sustainable growth. Recognizing the significance of existing urban centers empowers municipalities to strategically plan future development while preserving the municipality's unique identity. These elements form the backbone of the municipality's spatial development, contributing to its livability, functionality, and long-term sustainability.

### **1.5. Key Stakeholders & Inclusiveness**

Stakeholder analysis was conducted based on distinct roles and priorities of actors distributed across the municipality's climate change governance system. Further, actors were analysed by use of an Influence/Interest Matrix. Four quadrants were subsequently grouping, categorizing stakeholders into high influence-low interest; high influence-high interest; low influence-low interest; and low influence-high interest categories. Engagement strategies were then tailored to suit the needs of each quadrant thereby ensuring appropriate involvement throughout the process.

**Table 4: Stakeholder mapping for Emali - Sultan Hamud Municipality**

<p style="text-align: center;"><b>POWER/INFLUENCE</b></p>	<p><b>High Influence – Low Interest</b> <i>(Engagement approach is: Inform)</i></p> <ul style="list-style-type: none"> <li>• National line ministries</li> <li>• Utility service providers</li> <li>• The media</li> <li>• Development partners: World Bank, DANIDA, commercial banks</li> <li>• NoulTuresh Loitokitok Water and Sanitation Company Limited</li> <li>• Kenya Power</li> <li>• Kenya National Highways Authority</li> <li>• Kenya Urban Roads Authority</li> <li>• Kenya Rural Roads Authority</li> <li>• Civil Society Organizations</li> <li>• Tanathi Water Works Development Agency</li> </ul>	<p><b>High Influence – High Interest</b> <i>(Engagement approach is: Consult and Collaborate)</i></p> <ul style="list-style-type: none"> <li>• County Governor</li> <li>• County Executive</li> <li>• National Environment Management Authority</li> <li>• Emali - Sultan Hamud Municipal Board</li> <li>• National Drought Management Authority</li> <li>• Kenya Meteorological Department</li> <li>• County Climate Change Steering Committee</li> <li>• County climate change technical working group</li> <li>• Members of county assembly</li> <li>• Ward Climate Change Planning Committees</li> <li>• County Climate Change Unit</li> <li>• County Line Departments</li> </ul>
	<p><b>Low Influence – Low Interest</b> <i>(Engagement approach is: Monitor)</i></p> <ul style="list-style-type: none"> <li>• Residents of areas adjacent to the municipality</li> </ul>	<p><b>Low Influence – High Interest</b> <i>(Engagement approach is: Consult and Involve)</i></p> <ul style="list-style-type: none"> <li>• SMEs</li> <li>• Boda boda operators</li> <li>• <i>Jua kali</i> traders</li> <li>• National research institutions</li> <li>• Neighbourhood associations</li> <li>• Individual farmers</li> <li>• Vulnerable and marginalized groups</li> <li>• PWDs</li> <li>• Widowed households</li> <li>• Women and children</li> <li>• Elderly persons</li> </ul>
<p style="text-align: center;"><b>Low</b></p>	<p style="text-align: center;"><b>INTEREST</b></p>	<p style="text-align: center;"><b>High</b></p>

## 2. Hazard Assessment

Climate risk results from the interaction between and among hazard, exposure and vulnerability. Hazard refers to the potential occurrence of climate-related physical events or trends that may cause damage and/or loss. Exposure indicates the presence of assets, services, resources and infrastructure that could be adversely affected. Vulnerability on the other hand is the propensity or predisposition to be adversely affected. A climate hazard assessment identifies, evaluates, and prioritizes the physical impacts of climate change such as floods, droughts, heatwaves, and storms on assets, communities, and ecosystems. It determines risk by analyzing the intersection of hazard severity, exposure, and vulnerability, usually to facilitate adaptation actions. The following section highlights the key climate hazards within Emali - Sultan Hamud Municipality, highlighting the major concerns that should guide local climate action. This section is critical to understanding the municipality's vulnerability to climate change, by identifying and characterizing the most significant climate-related hazards.

The climatology of the larger Makueni County is generally dry, exhibiting semi-arid conditions. The local climate is influenced largely by the seasonal shifts and intensity of the Intertropical Convergence Zone (ITCZ). The average annual rainfall, evaporation and temperatures are 600mm, 200mm and 23°C, respectively and rainfall is characterized by small total amounts, strong seasonal and bimodal distribution.<sup>2</sup> Makueni County is largely an Arid and Semi-Arid Land (ASAL), making it prone to frequent droughts owing to unreliable and erratic rainfall. The county experiences erratic rainfall distributed in two rainy seasons, known locally as the long and short rainy seasons. The long rains are experienced during the March-April-May season, with the volume of rainfall averaging at 140mm over the last five years. Short rains are experienced during the October-November-December season, with higher volumes of precipitation being realized, with a five-year average of 300mm. The short rains are more reliable than the long rains. About 60% of the annual rainfall is received during the short rains while the long rains and the dry season contribute 37% and 3% of the annual rainfall, respectively.<sup>3</sup> The mean annual temperatures in Makueni range from 22.7°C to 24°C over the last five years.

Based on historical data and future projections, the initial screening process (Table 4) reveals that changes in precipitation patterns, specifically those leading to flooding, water stress and mass movement, as well as changes in surface temperatures expressed in heat stress are the most pressing high-priority threats for the municipality. The key hazards thus are heat stress, flooding, water stress and mass movement typified by gully erosion, especially in areas made susceptible owing to uncontrolled sand harvesting. These risks will thus form the focus of subsequent analysis, leading to their integration into urban planning and resilience strategies for the future development planning across the municipality.

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<sup>2</sup>Amukono, C. L. (2016). Agro-climatic characterization of Makueni County using rainfall data. Department of Meteorology, University of Nairobi, Kenya.

<sup>3</sup>Ibid.

## 2.1. Key Climate Hazards

The following matrix (Table 5) provides a summary of the key climate hazards that characterize development in Emali - Sultan Hamud Municipality.

**Table 5: Hazard screening for Emali - Sultan Hamud Municipality**

Hazard	Hazard Likely (Y/N)	Significant Impact (Y/N)	High Priority (Y/N)	Key Hazard (Y/N)
<b>Heat Stress</b>				
Average surface temperature increase	Y	Y	Y	Y
Extreme heat	Y	Y	N	N
<b>Flooding</b>				
Extreme precipitation	Y	Y	Y	Y
Pluvial (surface level) flooding, including flash flooding and urban flooding	Y	Y	Y	Y
<b>Water Stress</b>				
Drought (meteorological, hydrological)	Y	Y	Y	Y
<b>Mass Movement</b>				
Landslides	Y	N	N	N
Gully erosion	Y	Y	Y	Y

## 2.2. Climate Indicators and Hazard Thresholds

Presented in Table 6 is an indication of hazard thresholds for relevant climate indicators relevant for Emali - Sultan Hamud Municipality.

**Table 6: Climate indicators and hazard thresholds selected for the assessment**

Key Hazard	Climate indicator	Data source	Threshold		
			Low	Medium	High
Average surface temperature increase	Monthly temperature anomaly since 1979 (warmer than the 30 year climate mean of 1980–2010)	<a href="https://www.meteoblue.com/">https://www.meteoblue.com/</a>	Varies per month	Varies per month	Varies per month

Extreme precipitation	#days per year with precipitation >100mm #consecutive rainfall events with a total precipitation of 150mm	<a href="https://climateknowledgeportal.worldbank.org/country/kenya/era5-historical">https://climateknowledgeportal.worldbank.org/country/kenya/era5-historical</a>	Varies per year	Varies per year	Varies per year
Pluvial flooding	#days with precipitation >50mm	<a href="https://climateknowledgeportal.worldbank.org/country/kenya/era5-historical">https://climateknowledgeportal.worldbank.org/country/kenya/era5-historical</a>	<3 days /year	3-6 days/year	>6days /year
Prolonged dry spell	10 consecutive days with <10mm of precipitation	<a href="https://meteo.go.ke/">https://meteo.go.ke/</a>	Varies per month	Varies per month	Varies per month
Gully erosion	Vegetation coverage (VC), slope and main-branch gully ratio (MBGR)	Kimani (2024) <sup>4</sup> ; Makueni County CIDP 2023-2027			

### 2.3. Current Hazard Levels and Climate Projections

Makueni County, in which Emali - Sultan Hamud Municipality is located, has in the past recorded climate variability, accompanied by a significant increase in attendant risks, as repeatedly reported in the national news media. Historic analysis of weather in Makueni county shows that both dry spells and extreme precipitation are hazards in the county. Dry spells are on average longer during the second wet season, averaging close to 50 consecutive days of moisture stress, but ranging from 35 to 80 days in any given year. The first wet season experienced about 35 consecutive days of moisture stress, ranging from about 25 to 60 days in any given year. Extreme precipitation and flood risks are moderate in both seasons, with most years receiving between 20 and 30 mm of precipitation on the wettest day.

Climate has already been observed to change across the county. Since 1981, the first wet season with predominant high temperature and drought risk has experienced an approximately 10°C increase in mean temperature, bringing with it associated reduction in crop cycle time and an

<sup>4</sup> Kimani, C. K. (2024) An assessment of the causes and effects of degradation on riparian ecosystems of the eastern semi-arid region of Kenya; A case study of Kaiti river, Makueni County. MSc Thesis, South Eastern Kenya University.

additional 3-5 days with extreme heat stress ( $>35^{\circ}\text{C}$ ). Although there was no significant change in precipitation in this season, there was an increase in drought risk due to hotter temperatures. The second wet season experienced a small ( $< 0.5^{\circ}\text{C}$ ) change in temperature, no increase in heat stress days, and no significant change in precipitation, but continued to be affected by uncertain and highly variable rains.<sup>5</sup>

Located at an elevation of 1155.86m above sea level, Emali has a tropical wet and dry or savannah climate (Classification: Aw). The municipality's yearly temperature is  $25.23^{\circ}\text{C}$  and it is 2.73% higher than Kenya's average. Emali typically receives about 119.92 mm of precipitation and has 166.42 rainy days (45.59% of the time) annually. The highlands and middle zones receive an average rainfall of 1300 mm while the lower reaches of Nguu-Masumba, which is very dry, receives little rainfall ranging from 300 mm to 400 mm per annum. The Municipality experiences two rainy seasons, the long rains occurring in March-April while the short rains occur in November-December. The climate table (Figure xxx) provides a summary of weather by month in Emali-Sultan Hamud.

According to projections spanning the years of 2021-2065, prolonged moisture stress is expected to occur across both seasons of the year analyzed especially for first wettest season, whereas intense precipitation looks to change little. Within 30 years (by the early 2040's) temperature is projected to will have increased by  $0.2^{\circ}\text{C}$ , with the first wet season projected to experience even greater changes. And by this time, precipitation is projected to increase by 2% in the first wet season, and 17% in the second wet season. Consecutive days of moisture stress is projected to more than double in the first wet season from approximately 60 days to over 80-85 days depending on the amount of greenhouse gas emissions. In contrast, moisture stress in the second wet season is projected to reduce little on average (8% approximately). However, the second season is projected to receive more precipitation, and greater extremes in precipitation with climate change. For this season, the single day extreme rainfall is projected to increase by almost 50%. These projections of future climate change under the two climate scenarios – RCP 2.6 and RCP 8.5 – show some small differences, but generally show the same future projections, suggesting climate change impacts will be fairly similar during this time frame no matter the greenhouse gas emissions levels that occur.<sup>6</sup>

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<sup>5</sup> *Ibdi.*

<sup>6</sup> *Ibid.*

**Projected Timeseries of Average Mean Surface Air Temperature  
Makueni, Kenya 1950-2100 Multi-Model Ensemble Ref. Period: 1995-2014**

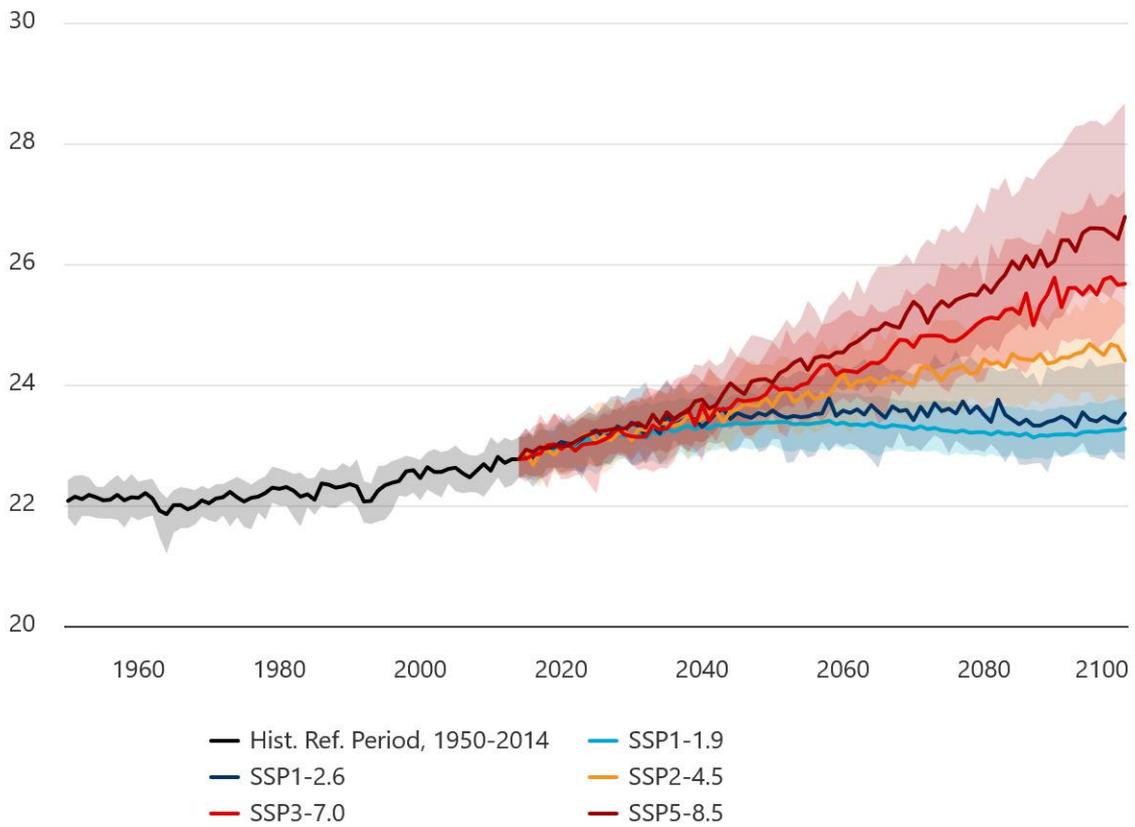


Figure 7: Projected average mean temperature<sup>7</sup>

Figure 1 provides a view of projected mean surface air temperature for the area up to 2100 under five different shared socioeconomic pathways (SSP) scenarios. Even with the ‘middle of the road’ (SSP2) pathway, the average temperatures still peak above 24°C, while the worst case scenario pushes things beyond 26.4°C

<sup>7</sup> Data from: <https://climateknowledgeportal.worldbank.org/country/kenya/climate-data-projections>

**Projected Timeseries of Average Largest Monthly Cumulative Precipitation  
Makueni, Kenya 1950-2100 Multi-Model Ensemble Ref. Period: 1995-2014**

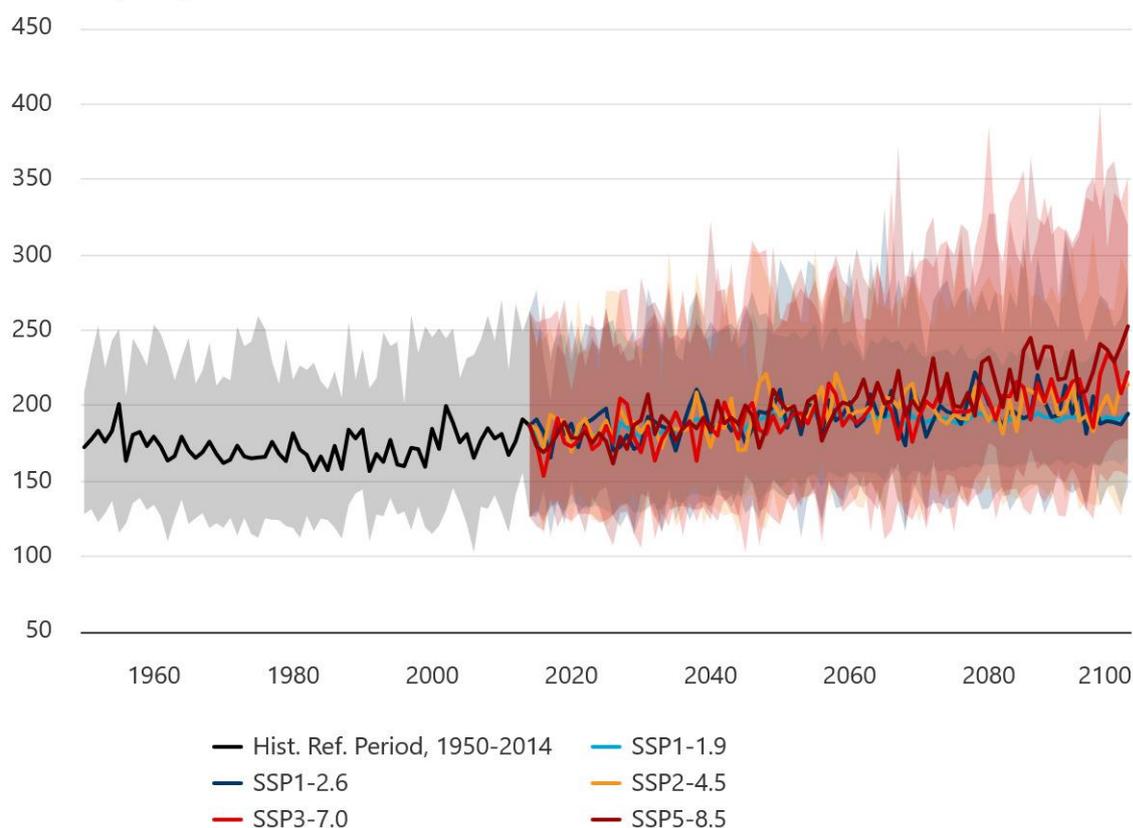


Figure 8: Projected average monthly precipitation<sup>8</sup>

Projected cumulative average monthly precipitation are presented in Figure 2. In general, the region is highly vulnerable to negative impacts of climate change due to low adaptive capacity and overreliance on rain-fed agriculture for food security and livelihoods.

Table 7 provides a summary of key hazards together with their levels of severity as experienced in Emali - Sultan Hamud Municipality.

**Table 7: Current and future hazards levels for Emali - Sultan Hamud Municipality**

Hazard	Hazard Level				
	Current (Baseline)	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
Average surface temperature increase	Low	Medium	High	Medium	High
Extreme precipitation	High	Medium	High	Medium	High
Pluvial flooding	High	High	High	High	High
Prolonged dry spell	Medium	Medium	High	Medium	High
Gully erosion	Medium	Medium	High	Medium	High

<sup>8</sup> Data from: <https://climateknowledgeportal.worldbank.org/country/kenya/climate-data-projections>

For this Urban Climate Risk Profile, hazard levels should be interpreted in accordance with the Table 8, with levels ranging from low to high.

**Table 8: 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

The identified hazards are currently spread out across the entire municipality, with some areas experiencing higher intensities. Figure 3, for example give an indication of climate risk areas in Kibwezi West Sub-county.

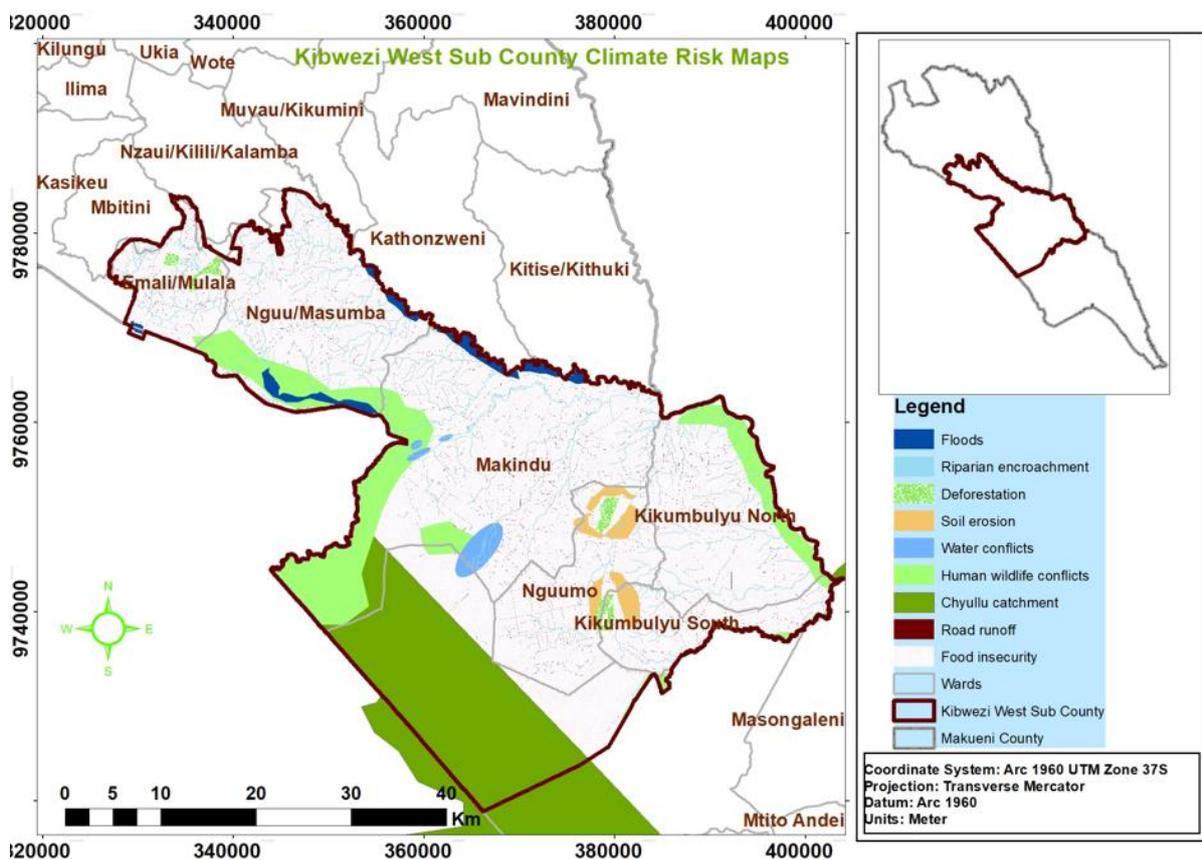


Figure 9: Climate impact areas in Kibwezi West Sub-county

The impact areas are a function of topography, hydrology and other parameters as captured in the following analysis.

### 3. Exposure & Vulnerability Assessment

Emali-Sultan Hamud Municipality has a tropical savannah climate, inflected by local topography. The highlands and middle zones receive an average rainfall of 1300 mm while the lower reaches of Nguu-Masumba, which is very dry, receives little rainfall ranging from 300 mm to 400 mm per annum. The Municipality experiences two rainy seasons, the long rains occurring in March-April while the short rains occur in November-December.

In recent years, the region’s vulnerability to climate challenges has grown due to erratic rainfall and rising temperatures. Extreme temperatures of up to 35°C, are causing heat stress, and the climate has become increasingly dry since the early 2000s. Future temperatures are expected to rise and persist longer. With time, rainy seasons have become shorter, more unpredictable, and more intense, leading to increased flashfloods and landslides, a trend likely to continue.

Rapid urbanization, population growth, and environmental degradation worsen the effects of floods and droughts. Poor drainage particularly in Emali and Sultan Hamud, the two commercial hubs within the municipality, makes inhabitants very vulnerable to flashfloods, leading to severe economic impacts. Moreover, deforestation within and beyond the municipality disrupts the water cycle and contributes to frequent droughts. Sand harvesting and poor waste management further exacerbate environmental degradation. These factors result in loss of life, property damage, water scarcity, and declines in biodiversity, livestock, and crops, contributing to food insecurity.

#### 3.1. Urban Elements

The following is an inventory of urban elements, together with their description as captured in this risk assessment (Table 9).

**Table 9: Urban elements inventory**

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
<b>Infrastructure &amp; Services</b>				
Storm water Drainage	Storm water drainage conveyance network	Y	N	Both lined and earth drains exist Mainly along bitumen standard roads within Emali and Sultan-Hamud townships
	Storm water storage	N	N	-
Water & Wastewater Management	Pumping stations	Y	N	
	Groundwater abstraction	Y	N	Boreholes serve 52% of the population
	Water treatment facilities	Y	N	

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Water supply networks	Y	N	Boreholes, shallow wells, protected springs, rock catchment and sub-surface dams the main sources of water. Nol Turesh Loitokitok Water and Sanitation Company the main supplier of water in the municipality.
	Sewer networks	Y	N	No reticulated sewerage system Pit latrines, ventilated improved pit (VIP) and soak pits used instead
	Wastewater treatment facilities			Localized septic tanks serve main institutions and some households There is a centralized treatment facility at Sultan Hamud that can handle the liquid waste in municipality, if properly operationalized.
Solid Waste Management	Transfer facilities	Y	N	
	Landfills and dump sites	Y	N	Emali town has a designated dumpsite while Sultan Hamud is temporarily being served by a non-designated dumpsite.
	Recycling centers	Y	N	
	Collection fleet	Y	N	No proper waste management plan
Transport and Mobility	Road networks	Y	Y	A few roads are tarmacked while most are graveled or graded and in a fair condition.
	Bridges	Y	N	
	Public transport networks (rail, bus, mini-bus, etc.)	Y	N	Matatus and boda bodas offer public transport.
	Transportation terminals	Y	N	Consist of matatu and boda boda stages
	Vehicle depots			
	Non-motorized transport networks	Y	N	Inadequate across municipality
	Freight and logistics hubs	N	N	Private courier companies like Wells Fargo, G4S, bus/matatu companies/saccos

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
Energy	Energy power plants	N	N	Connected to the national grid.
	Poles and power lines	N	N	
	Transformers and substations	Y	N	
	Street lighting	Y	N	Mostly in Emali Township
Economic Infrastructure	Markets	Y	Y	Facilities include open air markets, closed markets and livestock yards
	Businesses and commercial hubs	Y	N	Sultan Hamud, Emali, Mulala, Matiliku
	Industrial zones/parks and logistics parks	Y	Y	The municipality is designated as an industrial zone in the Makueni County Spatial Plan
Social Infrastructure	Government buildings and service centers	Y	N	
	Education facilities	Y	Y	
	Healthcare facilities	Y	Y	
	Public spaces	Y	N	
	Faith-based buildings	N	N	
	Cultural and heritage assets	N	N	
Emergency Services	Fire stations	Y	N	Fire risk is heightened by transit oil tankers that park in the municipality
	Police stations	Y	N	Several police stations and posts
	Telecommunications networks	Y	N	Safaricom, Airtel and Telkom networks adequately cover the municipality Mobile internet connection adequate across municipality
	Early warning systems	Y	N	
	Disaster management centers and shelters	Y	N	
	Evacuation routes	N	N	
	<b>Populations</b>			
Urban Residents	Population	Y	N	113,000 persons (2019 census)
	Households	Y	N	
Informal Settlement Residents	Population living in informal settlements	Y	N	
	Households lacking land tenure	Y	N	

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Households / residents lacking access to basic services	Y	N	
Vulnerable and Marginalized Groups	Low-income households	Y	N	
	Women-headed households	Y	N	
	Children and youth	Y	N	
	Elderly persons	Y	N	
	People with disabilities (PWD)	Y	N	
	Homeless populations	Y	N	Mainly street families in Emali and Sultan-Hamud townships
	Unemployed or precariously employed workers	Y	N	
	Seasonal workers / migrant laborers	N	N	
	Nomadic groups in peri-urban areas	N	N	
	Urban refugees and migrants	N	N	
	Minority ethnic groups in urban areas	N	N	
<b>Natural Assets</b>				
Urban Green Infrastructure	Urban parks and gardens	Y	Y	
	Green corridors	Y	N	
	Street landscaping	N	N	
	Urban forests and forest reserves	N	N	Nzaui, Makuli
Urban Blue Infrastructure	Natural wetlands	Y	N	
	Rivers	Y	Y	Muooni River, Ituti River, Yandia River, Volingi River, Myani, Muangini, Mikuyu and Enguli rivers
	Riparian zones	Y	Y	Along major rivers
	Lakes, ponds and reservoirs	N	N	
	Coastal ecosystems			
	Urban agriculture	N	N	
Peri-urban and Agricultural Systems	Peri-urban agriculture	Y	N	Prevalent in non-core areas of the municipality
	Agroforestry systems	Y	N	
	Forests and forest reserves	Y	N	

Category	Subcategory	Included in the RCRA (Y/N)	Available in GIS format (Y/N)	Description
	Protected areas and national parks	N	N	
	Savannahs and rangelands	N	N	

### 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 Table 10 below.

**Table 10: 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 (Table 11) summarizes likely impacts on each urban element by combining the assigned exposure and vulnerability levels.

**Table 11: Impact matrix**

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

**Table 12: 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
<b>Infrastructure &amp; Services</b>					
Storm water Drainage	<ul style="list-style-type: none"> <li>Can precipitate stronger storms accompanied by heavy downpour</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Water & Wastewater Management	<ul style="list-style-type: none"> <li>Resultant storms may disrupt water distribution networks when accompanied by heavy downpour that precipitate flooding and gully erosion</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Solid Waste Management	<ul style="list-style-type: none"> <li>Resultant storms may increase pluvial flooding that complicate SWM</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Transport and Mobility	<ul style="list-style-type: none"> <li>Heatwaves may impede use of non-motorized transport</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Energy	<ul style="list-style-type: none"> <li>Storm surges may destroy electricity distribution networks occasioning power outages</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Economic Infrastructure	<ul style="list-style-type: none"> <li>Traders in open-air markets will be more exposed to heatwaves reducing productivity due to heat stress</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Social Infrastructure	<ul style="list-style-type: none"> <li>Storm surges may destroy social amenities curtailing access</li> <li>Hospitals likely to experience a surge cases related to mental stress</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Emergency Services	<ul style="list-style-type: none"> <li>Freak storms may curtail timely access of emergency vehicles</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
<b>Populations</b>					
Urban Residents	<ul style="list-style-type: none"> <li>Most exposed to heatwaves due to localized impacts of urban heat island effects</li> <li>Increased heat stress and related mental effects</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Informal Settlement Residents	<ul style="list-style-type: none"> <li>Exposure to heatwaves owing to poor quality of residential units</li> <li>Exposure to heatwaves owing to jobs performed in the open sun</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	HIGH	CATASTROPHIC
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>Mostly exposed owing to precarious livelihoods often pursued in the open sun</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
<b>Natural Assets</b>					
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>Destruction of vegetation reducing the quality of green infrastructure</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>Drying up of rivers, shallow well and springs</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>Destruction of crops</li> <li>Loss of livestock</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	HIGH	CATASTROPHIC
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		

**Table 5: Exposure, Vulnerability, and Impacts of Extreme Precipitation on Urban Elements**

**Hazard:** Extreme precipitation

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
<b>Infrastructure &amp; Services</b>					
Stormwater Drainage	<ul style="list-style-type: none"> <li>Municipal storm water drainage systems is overwhelmed by surface runoff volumes</li> <li>Areas lacking drains easily become flooded</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High due to limited drainage network coverage</li> <li>Earth drains highly sensitive to topography which increases velocity of surface runoff</li> </ul>	HIGH	CATASTROPHIC
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low owing to inadequate maintenance</li> </ul>		
Water & Wastewater Management	<ul style="list-style-type: none"> <li>Water distribution network often damaged due to gully erosion</li> <li>Runoff contaminates surface and piped water supplies due to infiltration</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High owing to contamination and siltation of surface water sources</li> <li>Reduced efficiency of waste water disposal facilities</li> </ul>	HIGH	CATASTROPHIC

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<ul style="list-style-type: none"> <li>• Overflowing of septic tanks, soak pits and pit latrines due to runoff intrusion</li> <li>• Disruption of piped and surface water supplies</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low due to constrained water distribution networks</li> <li>• Limited capacity of existing waste water disposal/treatment facilities</li> </ul>		
Solid Waste Management	<ul style="list-style-type: none"> <li>• Delayed solid waste collection/transfer</li> <li>• Increased potential for ground water contamination by leachate</li> <li>• Solid wastes swept into drainage systems by surface runoff leading to clogging.</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High due to disruption in solid waste collection</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>	HIGH	CATASTROPHIC
Transport and Mobility	<ul style="list-style-type: none"> <li>• Dirt roads rendered impassable during heavy rains</li> <li>• Traffic flow disrupted on all major roads curtailing regional connection and internal circulation</li> <li>• Road and bridge infrastructure damaged by gully erosion</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High as key infrastructure and livelihoods are directly affected</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low due to limited livelihood and accessibility alternatives</li> </ul>	HIGH	CATASTROPHIC
Energy	<ul style="list-style-type: none"> <li>• Power outages caused by short-circuits and system faults in heavy storms</li> <li>• Increased transformer blow-outs owing to leakages into poorly-insulated equipment</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High due to disruption in power supply which affects the entire municipal economy</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low as it takes time to restore supply following outage</li> </ul>	MEDIUM	MODERATE
Economic Infrastructure	<ul style="list-style-type: none"> <li>• Traders in open markets are forced to close shop leading to income losses</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High due to direct impact on livelihoods</li> </ul>	MEDIUM	MAJOR

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<ul style="list-style-type: none"> <li>• Merchandize destroyed by rain</li> <li>• Reduced customers due to limited movement during heavy rains</li> <li>• Agro-processing plants receive reduced/poor quality produce due to disruption in transport</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low due to limited livelihood alternatives</li> </ul>		
Social Infrastructure	<ul style="list-style-type: none"> <li>• Sporadic damage to social infrastructure like school and health facilities occasioned by freak storms</li> <li>• Heavy rains curtails access household access to social facilities</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High to constrained access to social services</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low due to limited alternatives</li> </ul>	MEDIUM	MODERATE
Emergency Services	<ul style="list-style-type: none"> <li>• Extreme rainfall curtails emergency response when roads and bridges are cut off</li> <li>• Far-flung peri-urban areas most affected</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>	MEDIUM	MODERATE
<b>Populations</b>					
Urban Residents	<ul style="list-style-type: none"> <li>• Resident residing in downstream locations are affected by flash floods</li> <li>• Heightened runoff volumes affect surface water sources through contamination/siltation</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>	LOW	MINOR
Informal Settlement Residents	<ul style="list-style-type: none"> <li>• Residents experience poor drainage due to non-existent/blocked drains</li> <li>• Neighbourhoods cut off when roads become impassable</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>	MEDIUM	MAJOR
		HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High due to their powerlessness</li> </ul>	HIGH	CATASTROPHIC

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>• These often occupy precarious locations/shelter that are most vulnerable to floods/storms</li> <li>• Have precarious livelihoods that are easily disrupted by heavy rains</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low due to limited alternatives</li> </ul>		
<b>Natural Assets</b>					
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>• Parks cut off during heavy rains</li> <li>•</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• Medium</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>		
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>• Households that depend on shallow wells, protected springs and rivers suffer water contamination</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• Medium</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>		
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>• Loss of soil fertility due increased soil erosion and nutrient leaching</li> <li>• Destruction of crops</li> <li>• Loss of produce due to disruption in transportation networks</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>• High</li> </ul>	HIGH	CATASTROPHIC
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>• Low</li> </ul>		

**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
<b>Infrastructure &amp; Services</b>					
Storm water Drainage	<ul style="list-style-type: none"> <li>Majority of municipal drains are not lined</li> <li>Storm water drainage system is overwhelmed by surface runoff</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Earth drains are highly sensitive</li> <li>Lined drains are highly sensitive due to poor routine maintenance</li> </ul>	HIGH	<b>CATASTROPHIC</b>
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited coverage of the drainage network</li> </ul>		
Water & Wastewater Management	<ul style="list-style-type: none"> <li>Water distribution network often damaged due to gully erosion</li> <li>Surface runoff contaminates fresh water supply lines</li> <li>Septic tanks, soak pits and pit latrines overflow into water intake points</li> <li>Disruption of water supplies cuts of customers</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low as most water supply and waste water infrastructure is not within the pluvial flood zone</li> </ul>	MEDIUM	<b>MODERATE</b>
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to suboptimal distribution network and overstretched capacity</li> </ul>		
Solid Waste Management	<ul style="list-style-type: none"> <li>Littered/uncollected wastes swept into drainage channels causing blockage</li> <li>Minimal flooding at collection points, aggregation centres and disposal facility</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low as much of SWM infrastructure is not located within the pluvial flood zone</li> </ul>	LOW	<b>INSIGNIFICANT</b>
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High as the new facility as Kwa Kathoka presents an opportunity to modernize SWM</li> </ul>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Transport and Mobility	<ul style="list-style-type: none"> <li>Roads and bridges cut off during heavy rains</li> <li>Mobility curtailed, limiting access to markets, jobs and social amenities</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High as produce goes to waste, people lose livelihoods and fail to access social services...</li> </ul>	HIGH	CATASTROPHIC
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited alternatives once main connecting roads are cut off</li> </ul>		
Energy	<ul style="list-style-type: none"> <li>Limited disruption of energy supply</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low as much energy supplies are not affected by pluvial flooding</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High as energy sources are largely out of the pluvial zone</li> </ul>		
Economic Infrastructure	<ul style="list-style-type: none"> <li>Some markets flood during heavy downpour</li> <li>Agro-processing factories starved of fresh supplies when roads are cut off</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High as livelihoods are directly affected</li> </ul>	HIGH	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low owing to limited livelihood alternatives</li> </ul>		
Social Infrastructure	<ul style="list-style-type: none"> <li>Some schools, health facilities cut off during heavy downpour</li> <li>Increased school absenteeism and limited access to healthcare during rainy seasons</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low as not many facilities are affected</li> </ul>	MEDIUM	MINOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low as alternatives are limited by spatial fixity. People cannot access alternative schools/health facilities owing to their fixed locations</li> </ul>		
Emergency Services	<ul style="list-style-type: none"> <li>Flooding is likely to curtail access to emergency vehicles when roads are cut off</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
<b>Populations</b>					
Urban Residents	<ul style="list-style-type: none"> <li>Urban populations are more exposed to impacts of flooding</li> <li>Likely to experience more destruction of property and livelihoods</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium due to low numbers at risk</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Informal Settlement Residents	<ul style="list-style-type: none"> <li>Residents highly exposed to impacts of flooding</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>These have the most exposed owing to their precarious livelihoods</li> <li>Inadequate protections to cushion them from the vagaries of flooding</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	HIGH	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited livelihood alternatives</li> </ul>		
<b>Natural Assets</b>					
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>Parks and other recreational areas not significantly affected by pluvial flooding</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>		
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>Households that depend on shallow wells and protected springs are cut off due to contamination by surface runoff</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	MINOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>Destruction of crops on low-lying floodplains</li> <li>Inaccessibility to markets when roads are cut off by floods</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High owing to largely agro-dependent livelihoods</li> </ul>	MEDIUM	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited livelihood alternatives</li> </ul>		

**Table 15: Exposure, Vulnerability, and Impacts of Prolonged Dry Spell on Urban Elements**

**Hazard:** Prolonged dry spell

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
<b>Infrastructure &amp; Services</b>					
Stormwater Drainage	<ul style="list-style-type: none"> <li>Limited implications for storm drainage</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
Water & Wastewater Management	<ul style="list-style-type: none"> <li>Drought lead to reduction in volumes of water supplied, hence reduced industrial and agricultural produce as well as lower household welfare</li> <li>Compromised livelihoods</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High as water supply affects all sectors of the municipal economy</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited supply alternatives</li> </ul>	HIGH	CATASTROPHIC
Solid Waste Management	<ul style="list-style-type: none"> <li>Limited implications</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
Transport and Mobility	<ul style="list-style-type: none"> <li>Pedestrians more likely to face heat stress</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
Energy	<ul style="list-style-type: none"> <li>Limited implications</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
Economic Infrastructure	<ul style="list-style-type: none"> <li>Traders in open-air markets exposed to heat stress</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<ul style="list-style-type: none"> <li><i>Boda boda</i> riders exposed to heat stress</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>		
Social Infrastructure	<ul style="list-style-type: none"> <li>Hospitals may have to deal more cases of thermal stress</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
Emergency Services	<ul style="list-style-type: none"> <li>Wild fires more likely to occur</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	LOW	INSIGNIFICANT
<b>Populations</b>					
Urban Residents	<ul style="list-style-type: none"> <li>More likely to experience heat stress due to localized urban heat island effects</li> <li>Water supply shortages</li> </ul>	MAJOR	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MAJOR
Informal Settlement Residents	<ul style="list-style-type: none"> <li>Residents more likely to experience thermal stress due to flimsy construction materials and livelihood pursuits that require working in the open sun</li> <li>Water supply shortages</li> </ul>	MAJOR	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MAJOR
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>These are most exposed due to their livelihoods, shelter conditions and limited power to influence decisions</li> <li>Water supply shortages</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MAJOR
<b>Natural Assets</b>					
Urban Green Infrastructure		MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MAJOR	MAJOR

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<ul style="list-style-type: none"> <li>Parks and other green areas suffer vegetation stress, hence become less appealing to users</li> <li>Overuse by populations seeking shelter from scorching heat</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>Seasonal rivers dry up, as do shallow wells and springs</li> <li>Water supply shortages</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MAJOR	MAJOR
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>Droughts cause destruction of crops</li> <li>Loss of livestock</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	HIGH	CATASTROPHIC

**Table 16: Exposure, Vulnerability, and Impacts of Gully Erosion on Urban Elements**

**Hazard:** Gully erosion

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
<b>Infrastructure &amp; Services</b>					
Stormwater Drainage	<ul style="list-style-type: none"> <li>Destruction of unlined earth drains</li> <li>Gullies deliver unprecedented runoff volumes that flood downstream land uses</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MAJOR
Water & Wastewater Management	<ul style="list-style-type: none"> <li>Destruction of water distribution networks</li> <li>Destruction of wastewater disposal facilities</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MAJOR

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Solid Waste Management	<ul style="list-style-type: none"> <li>Limited implications</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>		
Transport and Mobility	<ul style="list-style-type: none"> <li>Destruction of key transport infrastructure such as roads and bridges cutting of mobility and accessibility</li> </ul>	HIGH	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High due to centrality of transportation in the municipal economy and welfare</li> </ul>	MEDIUM	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low due to limited alternatives</li> </ul>		
Energy	<ul style="list-style-type: none"> <li>Limited implications</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	LOW	INSIGNIFICANT
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>		
Economic Infrastructure	<ul style="list-style-type: none"> <li>Roads cut off by gully erosion curtail access to markets</li> <li>Destruction of farmlands</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Social Infrastructure	<ul style="list-style-type: none"> <li>Roads cut off by gully erosion curtail access to social amenities</li> <li>Destruction of social facilities</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>	MEDIUM	MODERATE
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>		
Emergency Services	<ul style="list-style-type: none"> <li>Roads cut off by gully erosion curtail access, impeding emergency response</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MINOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
<b>Populations</b>					
Urban Residents	<ul style="list-style-type: none"> <li>Those living downstream are exposed to flash floods</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	MEDIUM	MODERATE

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
	<ul style="list-style-type: none"> <li>Residents cut off when roads and bridges are destroyed by gully erosion</li> <li>Outages in water supply when distribution networks are destroyed by gully erosion</li> </ul>		<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		
Informal Settlement Residents	<ul style="list-style-type: none"> <li>Neighbourhoods located downstream are exposed to flash floods</li> <li>Residents cut off when roads and bridges are destroyed by gully erosion</li> <li>Outages in water supply when distribution networks are destroyed by gully erosion</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	MEDIUM	MODERATE
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>Greatly exposed when roads and water supply are cut off</li> <li>Livelihoods suffer when infrastructure and social amenities are destroyed by gully erosion</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>	HIGH	MAJOR
<b>Natural Assets</b>					
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>Parks and green areas destroyed by gully erosion</li> <li>Access to these green facilities impeded when roads and access paths are cut off by erosion</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>	MEDIUM	MODERATE
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>Rivers, springs destroyed by gully erosion</li> </ul>	LOW	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul> <b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Medium</li> </ul>	LOW	INSIGNIFICANT

Category	Exposure (Description)	Exposure Level	Vulnerability (Description)	Vulnerability Level	Impact Level
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>Farmlands destroyed by gully erosion</li> <li>Access to markets impeded when roads are cut off by gully erosion</li> </ul>	MEDIUM	<b>Sensitivity:</b> <ul style="list-style-type: none"> <li>High</li> </ul>	HIGH	MAJOR
			<b>Adaptive Capacity:</b> <ul style="list-style-type: none"> <li>Low</li> </ul>		

## 4. Climate Risk Assessment

The Municipality today faces unprecedented and uncertain risks associated with climate change. The rising urban population and continued migration into the municipality tends to concentrate people in ecologically fragile areas, which are particularly prone to the risk of natural disasters linked to climate change. Furthermore, many of the new urban dwellers have little by way of financial means to recover from a disaster. As urbanizing trends increase, so too will the importance of risk assessment and resilience planning across the municipality. Risk assessment process can help a community understand the resources it will need to invest in and how it might prioritize strategies to reduce the risk. The assessment proceeds by identifying the types of events that could occur in the municipality, the probability that events of varying severity will occur, and the consequences of those events, including economic, infrastructure, socio-cultural, and public health losses.

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 17: Risk matrix**

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

For this Urban Climate Risk Profile, risk levels should be interpreted based on Table 18 below.

**Table 18: 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

Below is summary of the current and future climate risks elements as experienced in Emali - Sultan Hamud Municipality.

**Table 19: Summary of average surface temperature increase risks for Emali - Sultan Hamud Municipality**

	<b>Time Horizon &amp; Climate Scenario</b>	Current	2050 SSP2- 4.5	2050 SSP5- 8.5	2100 SSP2- 4.5	2100 SSP5- 8.5
	<b>Hazard Level</b>					
<b>Categories</b>	<b>Impact</b>	<b>Risk Levels</b>				
		<b>Current</b>	<b>2050 SSP2- 4.5</b>	<b>2050 SSP5- 8.5</b>	<b>2100 SSP2- 4.5</b>	<b>2100 SSP5- 8.5</b>
<b>Infrastructure &amp; Services</b>						
Storm water Drainage	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Water & Wastewater Management	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Solid Waste Management	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Transport and Mobility	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Energy	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Economic Infrastructure	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Social Infrastructure	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Emergency Services	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
<b>Populations</b>						
Urban Residents	<b>MAJOR</b>	High	High	High	High	High
Informal Settlement Residents	<b>CATASTROPHIC</b>	High	High	High	High	High
Vulnerable and Marginalized Groups	<b>MAJOR</b>	High	High	High	High	High
<b>Natural Assets</b>						
Urban Green Infrastructure	<b>MAJOR</b>	Medium	Medium	Medium	Medium	Medium
Urban Blue Infrastructure	<b>MODERATE</b>	Medium	Medium	Medium	Medium	Medium
Peri-urban and Agricultural Systems	<b>CATASTROPHIC</b>	Very high	Very high	Very high	Very high	Very high

**Table 20: Summary of extreme precipitation risks for Emali - Sultan Hamud Municipality**

	<b>Time Horizon &amp; Climate Scenario</b>	Current	2050 SSP2- 4.5	2050 SSP5- 8.5	2100 SSP2- 4.5	2100 SSP5- 8.5
	<b>Hazard Level</b>					
<b>Categories</b>	<b>Impact</b>	<b>Risk Levels</b>				
		<b>Current</b>	<b>2050 SSP2- 4.5</b>	<b>2050 SSP5- 8.5</b>	<b>2100 SSP2- 4.5</b>	<b>2100 SSP5- 8.5</b>
<b>Infrastructure &amp; Services</b>						
Storm water Drainage	<b>CATASTROPHIC</b>	Very high	Very high	Very high	Very high	Very high
Water & Wastewater Management	<b>CATASTROPHIC</b>	High	High	High	High	High
Solid Waste Management	<b>CATASTROPHIC</b>	High	High	High	High	High
Transport and Mobility	<b>CATASTROPHIC</b>	Very high	Very high	Very high	Very high	Very high
Energy	<b>MODERATE</b>	Medium	Medium	Medium	Medium	Medium
Economic Infrastructure	<b>MAJOR</b>	High	High	High	High	High
Social Infrastructure	<b>MODERATE</b>	Medium	Medium	Medium	Medium	Medium
Emergency Services	<b>MODERATE</b>	Medium	Medium	Medium	Medium	Medium
<b>Populations</b>						
Urban Residents	<b>MINOR</b>	Medium	Medium	Medium	Medium	Medium
Informal Settlement Residents	<b>MAJOR</b>	High	High	High	High	High
Vulnerable and Marginalized Groups	<b>CATASTROPHIC</b>	High	High	High	High	High
<b>Natural Assets</b>						
Urban Green Infrastructure	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Urban Blue Infrastructure	<b>INSIGNIFICANT</b>	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	<b>CATASTROPHIC</b>	High	High	High	High	High

**Table 21: Summary of pluvial flooding risks for Emali - Sultan Hamud Municipality**

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level					
Categories	Impact	Risk Levels				
		Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
<b>Infrastructure &amp; Services</b>						
Storm water Drainage	CATASTROPHIC	Very high	Very high	Very high	Very high	Very high
Water & Wastewater Management	MODERATE	High	High	High	High	High
Solid Waste Management	INSIGNIFICANT	Medium	Medium	Medium	Medium	Medium
Transport and Mobility	CATASTROPHIC	High	High	High	High	High
Energy	INSIGNIFICANT	Low	Low	Low	Low	Low
Economic Infrastructure	MAJOR	High	High	High	High	High
Social Infrastructure	MINOR	Medium	Medium	Medium	Medium	Medium
Emergency Services	MODERATE	Medium	Medium	Medium	Medium	Medium
<b>Populations</b>						
Urban Residents	MODERATE	High	High	High	High	High
Informal Settlement Residents	MODERATE	High	High	High	High	High
Vulnerable and Marginalized Groups	MAJOR	High	High	High	High	High
<b>Natural Assets</b>						
Urban Green Infrastructure	INSIGNIFICANT	Very low	Very low	Very low	Very low	Very low
Urban Blue Infrastructure	MINOR	Low	Low	Low	Low	Low
Peri-urban and Agricultural Systems	MAJOR	High	High	High	High	High

**Table 22: Summary of prolonged dry spell risks for Emali - Sultan Hamud Municipality**

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level					
Categories	Impact	Risk Levels				
		Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
<b>Infrastructure &amp; Services</b>						
Storm water Drainage	INSIGNIFICANT	Low	Low	Low	Low	Low
Water & Wastewater Management	CATASTROPHIC	High	High	High	High	High
Solid Waste Management	INSIGNIFICANT	Low	Low	Low	Low	Low
Transport and Mobility	INSIGNIFICANT	Low	Low	Low	Low	Low
Energy	INSIGNIFICANT	Low	Low	Low	Low	Low
Economic Infrastructure	INSIGNIFICANT	Low	Low	Low	Low	Low
Social Infrastructure	INSIGNIFICANT	Low	Low	Low	Low	Low
Emergency Services	INSIGNIFICANT	Low	Low	Low	Low	Low
<b>Populations</b>						
Urban Residents	MAJOR	High	High	High	High	High
Informal Settlement Residents	MAJOR	High	High	High	High	High
Vulnerable and Marginalized Groups	MAJOR	High	High	High	High	High
<b>Natural Assets</b>						
Urban Green Infrastructure	MAJOR	Medium	Medium	Medium	Medium	Medium
Urban Blue Infrastructure	MAJOR	High	High	High	High	High
Peri-urban and Agricultural Systems	CATASTROPHIC	Very high	Very high	Very high	Very high	Very high

**Table 23: Summary of gully erosion risks for Emali - Sultan Hamud Municipality**

	Time Horizon & Climate Scenario	Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
	Hazard Level					
Categories	Impact	Risk Levels				
		Current	2050 SSP2-4.5	2050 SSP5-8.5	2100 SSP2-4.5	2100 SSP5-8.5
<b>Infrastructure &amp; Services</b>						
Stormwater Drainage	MAJOR	High	High	High	High	High
Water & Wastewater Management	MAJOR	High	High	High	High	High
Solid Waste Management	INSIGNIFICANT	Low	Low	Low	Low	Low
Transport and Mobility	MAJOR	High	High	High	High	High
Energy	INSIGNIFICANT	Very low	Very low	Very low	Very low	Very low
Economic Infrastructure	MODERATE	High	High	High	High	High
Social Infrastructure	MODERATE	Medium	Medium	Medium	Medium	Medium
Emergency Services	MINOR	Low	Low	Low	Low	Low
<b>Populations</b>						
Urban Residents	MODERATE	Medium	Medium	Medium	Medium	Medium
Informal Settlement Residents	MODERATE	Medium	Medium	Medium	Medium	Medium
Vulnerable and Marginalized Groups	MAJOR	High	High	High	High	High
<b>Natural Assets</b>						
Urban Green Infrastructure	MODERATE	Low	Low	Low	Low	Low
Urban Blue Infrastructure	INSIGNIFICANT	Very low	Very low	Very low	Very low	Very low
Peri-urban and Agricultural Systems	MAJOR	Very high	Very high	Very high	Very high	Very high

## 4.2. Climate Risk Hotspots

Climate risks vary between different sub-counties and wards across the municipality. This spatial variation in risk spread has significant implications in times prioritization and targeting of climate action across the municipality. Figure 10 for example provides an indication of risks spread across Kibwezi West Sub-county. Many of these risks are correlated with the topographical formation of the various wards, with forested areas likely to experience forest fires, while downstream locations are likely to experience pluvial flooding (see Figure 11).

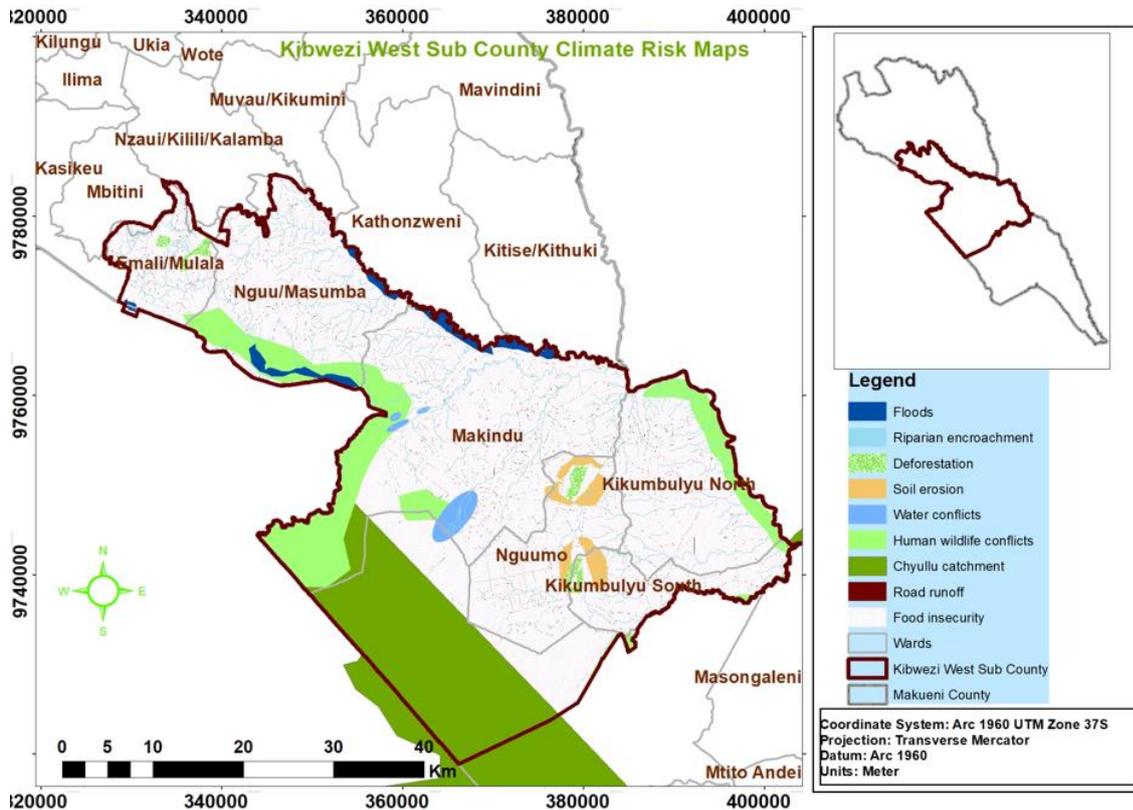


Figure 10: Climate risk hotspots in Kibwezi West Sub-county



## 5. What's Next?

### 5.1. Key Findings

Following the foregoing analysis, below is a summary of the hazards in Emali – Sultan Hamud Municipality, including those that are associated with higher risks, populations and assets that are most at risk, as well as trends that are most likely to intensify in the future, referring back to the future trends recorded.

**Table 6: Summary of climate risks affecting urban elements for Emali - Sultan Hamud Municipality**

Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
<b>Infrastructure &amp; Services</b>			
Storm water Drainage	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>
Water & Wastewater Management	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>
Solid Waste Management	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>
Transport and Mobility	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>
Energy	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>
Economic Infrastructure	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> <li>• Gully erosion</li> </ul>
Social Infrastructure	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>	<ul style="list-style-type: none"> <li>• Extreme precipitation</li> </ul>
Emergency Services			

Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
<b>Populations</b>			
Urban Residents	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>
Informal Settlement Residents	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> </ul>
<b>Natural Assets</b>			
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Pluvial flooding</li> </ul>

Category	List of Key Hazards		
	Current	Mid-term (2050)	Long-term (2100)
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Average surface temperature increase</li> <li>• Extreme precipitation</li> <li>• Pluvial flooding</li> <li>• Gully erosion</li> </ul>

Based on the key hazards identified, together with the urban elements/sector that they impact mostly, a myriad of interventions has been proposed to inform climate action in Sultan-Hamud, spanning the short-, medium and long-term horizons. These are provided in Section 5.2 below.

## 5.2. Climate Adaptation and Resilience Solutions

Here, we provide a summary list of adaptation and resilience solutions that will address the key hazards for each urban element category listed in the previous Section 5.1.

**Table 25: Adaptation and resilience solutions**

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
<b>Infrastructure &amp; Services</b>			
Storm water Drainage	<ul style="list-style-type: none"> <li>• Desilting/cleaning up clogged drainage channels</li> <li>• Opening up of earth drainage channels in areas of need</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of infiltration trenches in flood-prone public areas</li> <li>• Stone-pitching of unlined earth drains to prevent formation of gullies</li> </ul>	<ul style="list-style-type: none"> <li>• Establishment of bioswales along public streets and other drainage courses</li> <li>• Incorporate on-site runoff management systems for new residential and institutional developments</li> <li>• Adoption of permeable pavements and green roofs to enhance runoff percolation</li> <li>• Enforcement of building density and zoning regulations to control the amount of buildable space per development site</li> </ul>
Water & Wastewater Management	<ul style="list-style-type: none"> <li>• Inspection and repair flood-damaged pipes and treatment facilities</li> <li>• Promotion of water use efficiency</li> </ul>	<ul style="list-style-type: none"> <li>• Development of early warning systems for waste water overflow, especially during the rainy season</li> <li>• Adoption of roof catchment and water harvesting systems for homes and institutions</li> </ul>	<ul style="list-style-type: none"> <li>• Elevation or relocation of waste water infrastructure in high-risk zones</li> <li>• Installation of bulk rainwater harvesting systems</li> <li>• Climate-proofing of the water supply network</li> </ul>

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Solid Waste Management	<ul style="list-style-type: none"> <li>Clearing drains of solid wastes ahead of the rainy season</li> <li>Enforcement of SWM regulations across the municipality</li> </ul>	<ul style="list-style-type: none"> <li>Conduct public awareness campaigns on SWM</li> <li>Relocate waste collection and transfer sites away from riparian areas and flood-prone zones</li> <li>Installation of appropriate waste receptacles in public spaces</li> </ul>	<ul style="list-style-type: none"> <li>Adopt the circular economy model to encourage more efficient SWM practices</li> <li>Construction of material recovery centres across the municipality</li> <li>Institutionalize waste separation and recycling to reduce waste volumes</li> </ul>
Transport and Mobility	<ul style="list-style-type: none"> <li>Installation of temporary barriers to control entry into flooded areas</li> <li>Provision of alternative crossing points across rivers cut off by floods</li> </ul>	<ul style="list-style-type: none"> <li>Upgrading of critical road sections and bridges to withstand higher flood water volumes</li> </ul>	<ul style="list-style-type: none"> <li>Adoption of flood-proof design concepts in the construction of roads and bridges</li> <li>Opening of alternative access routes to enhance mobility during rainy weather</li> </ul>
Economic Infrastructure	<ul style="list-style-type: none"> <li>Provision of trader sheds in municipal markets</li> </ul>	<ul style="list-style-type: none"> <li>Support traders to embrace nature-based solutions as alternative livelihood pursuits</li> <li>Sensitization of traders to utilize climate information to minimize disruption and losses</li> </ul>	<ul style="list-style-type: none"> <li>Erection of modern markets complete with requisite utility supplies</li> <li>Relocation of markets situated in flood-prone locations</li> <li>Improvement of road conditions connecting farmers to markets and agro-processing factories</li> </ul>
Social Infrastructure	<ul style="list-style-type: none"> <li>Provide alternative temporary access for those cut off during floods</li> </ul>	<ul style="list-style-type: none"> <li>Retrofit all social facilities destroyed by floods</li> <li>Relocate facilities in flood-prone zones</li> </ul>	<ul style="list-style-type: none"> <li>Develop long-term disaster management plans for all municipal facilities</li> <li>Adopt climate-proof designs for all social amenities</li> </ul>
<b>Populations</b>			
Urban Residents	<ul style="list-style-type: none"> <li>Dissemination of real-time flood warning using multiple channels and platforms</li> </ul>	<ul style="list-style-type: none"> <li>Promotion of rain harvesting systems to promote self-sufficiency and reduce runoff</li> </ul>	<ul style="list-style-type: none"> <li>Review, implement/enforce zoning regulations to ensure appropriate development control, especially in flood-risk areas</li> </ul>

Category	Recommended Solutions		
	Immediate	Mid-term	Long-term
Informal Settlement Residents	<ul style="list-style-type: none"> <li>Dissemination of real-time flood warning using multiple channels and platforms</li> </ul>	<ul style="list-style-type: none"> <li>Installation of communal water points in elevated areas</li> </ul>	<ul style="list-style-type: none"> <li>Upgrading of settlements through adequate infrastructure provision</li> <li>Relocation of settlements when they are situated in flood-risk areas</li> </ul>
Vulnerable and Marginalized Groups	<ul style="list-style-type: none"> <li>Prioritization of targeted assistance for the elderly, disabled, widows, and households headed by women</li> </ul>	<ul style="list-style-type: none"> <li>Operationalization of ward climate change planning committees to spearhead local climate action</li> </ul>	<ul style="list-style-type: none"> <li>Integration of climate action into social protection and poverty reduction programming</li> </ul>
<b>Natural Assets</b>			
Urban Green Infrastructure	<ul style="list-style-type: none"> <li>Removal of debris and sediments from urban parks post-flooding</li> </ul>	<ul style="list-style-type: none"> <li>Rehabilitation and expansion of existing green spaces to facilitate percolation of surface runoff</li> <li>Establishment of high-value assorted tree nurseries</li> </ul>	<ul style="list-style-type: none"> <li>Adoption of nature-based solutions in municipal development planning</li> </ul>
Urban Blue Infrastructure	<ul style="list-style-type: none"> <li>Fence off protected springs and shallow wells to protect them from runoff intrusion</li> </ul>	<ul style="list-style-type: none"> <li>Establishment of constructed wetlands to help manage flood risk in sensitive areas</li> </ul>	<ul style="list-style-type: none"> <li>Restoration of natural meanders and degraded vegetation on riparian reserves</li> <li>Establishment of riverine parks as part of the municipal green/blue infrastructure</li> </ul>
Peri-urban and Agricultural Systems	<ul style="list-style-type: none"> <li>Dissemination of real-time agro-climate/weather information using multiple channels and platforms</li> </ul>	<ul style="list-style-type: none"> <li>Provision of certified seeds and other farm inputs attuned to climate change</li> <li>Dissemination of climate-appropriate farming techniques</li> </ul>	<ul style="list-style-type: none"> <li>Implementation of watershed management plans</li> <li>Promotion of climate-resilient farming practices</li> <li>Promotion of climate insurance to cushion farmers from climate-induced losses</li> </ul>

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