

Adapting Together, Thriving Tomorrow



Climate Change Rapid Risk Assessment and Adaptation Plan for Tema Metropolitan Assembly, Ghana

Enhancing Multi-Sector
Planning and Capacity
for Effective Adaptation
in Ghana



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Acronyms

Abbreviation	Connotation
°C	Degree Celsius
AAP	Annual Action Plan
AEAs	Agricultural Extension Agents
AG	Assemblies Of God
ATMA	Accra-Tema Metropolitan Assembly
CCV	Climate Change Vulnerability
CO ₂	Carbon dioxide
DRR	Disaster And Risk Reduction
EPA	Environmental Protection Agency
GCF	Green Climate Fund
GHG	Green House Gases
GSS	Ghana Statistical Service
IPCC	Intergovernmental Platform of Climate Change
M&E	Monitoring And Evaluation
MCA	Multi Criteria Analysis
MEL	Monitoring, Evaluation And Learning
MESTI	Ministry Of Environment, Science, Technology, And Innovation
MMDAs	Metropolitan, Metropolitan , And District Assemblies
MTDP	Medium-Term Development Plan
NADMO	National Disaster Management Organization
NAP	National Adaptation Planning
NDC	Nationally Determined Contributions
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organizations
PLWD	Persons Living With Disabilities
PPPs	Public- Private Partnerships
PWD	Persons With Disabilities
RA	Risk Assessment
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SREX	Special Report for Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SSP	Shared Socio-economic Pathways
TAP	Tema Adaptation Plan
TMA	Tema Metropolitan Assembly
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention On Climate Change
VA	Vulnerability Assessment
WHO	World Health Organisation



1



Introduction

1.1 Background

Globally, climate change is recognized as one of the most pressing challenges of the 21st century, with far-reaching implications for environmental sustainability, socioeconomic development, and geopolitical stability. Rising greenhouse gas emissions from human activities have led to unprecedented shifts in weather patterns, including more frequent and intense extreme weather events such as floods, droughts, hurricanes, and heatwaves. Within the West African region, countries are particularly vulnerable to the impacts of climate change due to their dependence on rain-fed agriculture, high population density in coastal areas, and limited adaptive capacity. Moreover, the region's vulnerability is compounded by socio-economic factors such as poverty, rapid urbanization, and inadequate infrastructure, which constrain adaptation efforts and increase the risk of climate-induced disasters.

In Ghana, climate change poses significant threats to sustainable development and human well-being across various sectors, including agriculture, water resources, health, and infrastructure. The country has witnessed an increase in the frequency and severity of extreme weather events, with devastating consequences for rural livelihoods, urban settlements, and natural ecosystems.

Within the Greater Accra region of Ghana, the Tema Metropolitan Assembly stands out as a hotspot of climate vulnerability, characterized by a high population density, rapid urbanization, and exposure to coastal hazards. The TMA faces a dual threat from both inland and coastal climate risks, including floods, droughts, sea-level rise, and storm surges, which pose significant challenges to infrastructure, livelihoods, and public health. Moreover, the socio-economic disparities within the TMA exacerbate the impacts of climate change, disproportionately affecting marginalized communities and exacerbating existing inequalities. These climatic disturbances not only undermine the livelihoods of local populations but also heighten socioeconomic vulnerabilities, threatening the region's sustainable development trajectory.

Following from this context and like many other African countries, Ghana needs to reinforce its defences against the adverse impacts of environmental changes urgently in view of the growing effects of climate change. The need for adaptation measures to mitigate the effects of climate change is becoming widely acknowledged. Adaptation not only increases community resilience but also helps achieve sustainable development objectives, protect ecosystems, and advance socioeconomic stability. In light of the growing need of proactive adaption methods in the midst rising climate hazards, developing Ghana's National Adaptation Plans (NAPs) that fully address risks associated with climate change while enhancing resilience across all sectors then becomes a necessity.

Ghana has started the process of developing its Nationally Action Plan (NAP) framework. The Tema Metropolitan Assembly is one of the districts selected for climate risk assessments from Ghana's agro-ecological zones, highlighting its importance in the country's adaptation planning process. With the help of all stakeholders and a strong NAP, Ghana will be able to allocate resources effectively, carry out focused interventions, and win over support from all parties involved in a coordinated and inclusive manner.

The Climate Change Risk Assessment (CCRA) for the Tema Metropolitan Assembly (TMA) aims to identify, analyze, and prioritize climate-related risks in the area. It guides local experts and stakeholders in systematically evaluating TMA's vulnerability to climate change impacts, using the AR5 framework from the IPCC. The assessment seeks to provide a comprehensive overview of climate risks specific to TMA, enhance understanding of local vulnerabilities (including gender considerations), support adaptation planning with targeted strategies, promote stakeholder co-development, and align with national and regional climate change frameworks.

1.2 Objectives

The Government of Ghana, through the EPA and MESTI, has secured Green Climate Fund (GCF) support for a three-year initiative to enhance the National Adaptation Plan (NAP) process. Partnering with UNEP, the project focuses on integrating climate adaptation into national development policies, improving climate risk data systems, and establishing sustainable financing for adaptation. By conducting advanced climate risk assessments, the initiative aims to create a robust climate risk narrative to inform national and regional adaptation plans, support the updated NAP, and secure international climate finance, ultimately strengthening Ghana's resilience to climate change.

Specifically, this work on “Enhancing Multi-Sector Planning and Capacity for Effective Adaptation in Ghana,” seeks to advance climate resilience by focusing on two critical aspects: creating a robust national adaptation framework and enhancing local-level implementation capacity. The initiative emphasizes the development of a costed National Adaptation Plan (NAP) while simultaneously building the capacity of stakeholders within the Tema Metropolitan Assembly (TMA) to integrate climate adaptation considerations into their Medium-Term Development Plan (MTDP). This approach involves three interconnected components:

- **Conducting Rapid Climate Risk Assessments within the Tema Metropolitan Assembly:**

This step involves systematically identifying and analyzing the climate-related vulnerabilities and risks faced by TMA. The assessments focus on understanding the current and projected impacts of climate variability and change across key sectors within the Metropolis. This information serves as a baseline for planning and prioritizing adaptation actions.

- **Developing Costed Adaptation Plans for the Tema Metropolitan Assembly:**

Based on the risk assessments, detailed and financially costed adaptation plans will be prepared for the TMA. These plans will outline specific, actionable strategies tailored to local needs, addressing critical climate risks while ensuring alignment with broader national priorities. The costing will enable better resource allocation and help mobilize both public and private financing for implementation.

- **Formulating Prioritized Sectoral Adaptation Plans:**

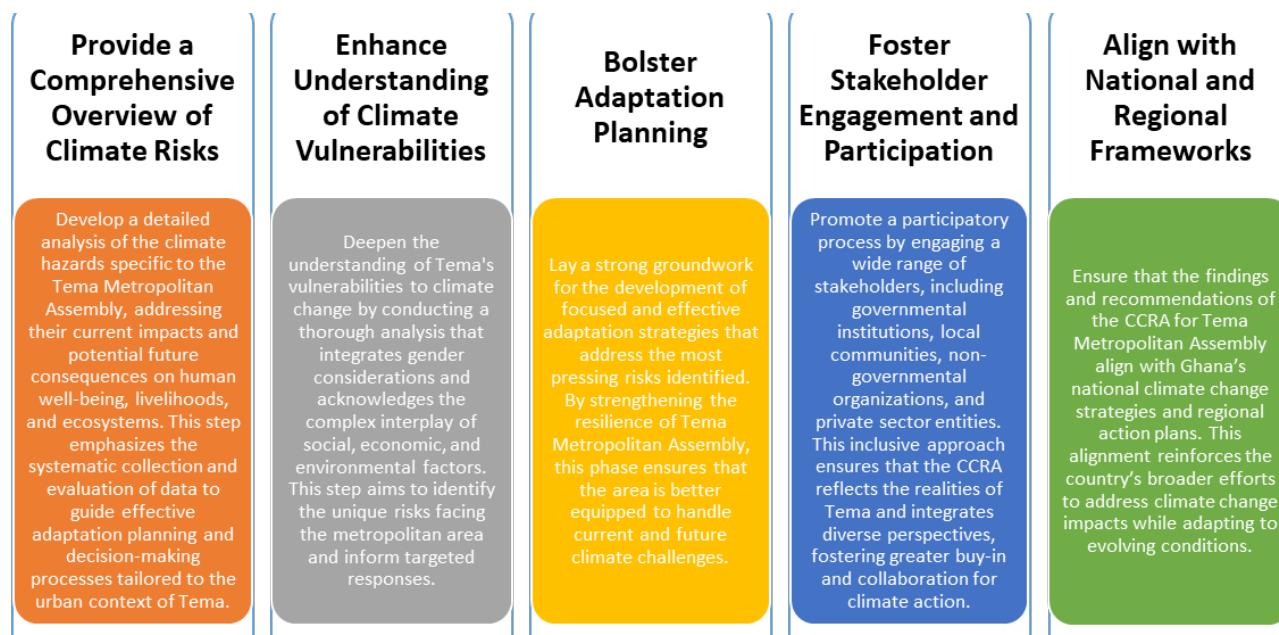
To ensure targeted and effective interventions, the study will identify and prioritize key sectors that are most vulnerable to climate impacts, such as agriculture, water resources, health, and infrastructure. Sector-specific adaptation strategies will be developed, incorporating inputs from multi-sectoral stakeholders to ensure inclusivity, feasibility, and alignment with sustainable development goals

1.3 Document Purpose

This report presents the Climate Change Risk Assessment (CCRA) for the Tema Metropolitan Assembly, focusing on up to four biophysical and three economic sector risk domains, developed through a participatory process with local stakeholders. Its primary aim is to support Metropolitan experts and stakeholders in evaluating the Metropolis's vulnerability to climate change impacts, using the IPCC's Fifth Assessment Report

(AR5) framework to integrate hazard, exposure, and vulnerability components. The CCRA seeks to validate critical findings, identify and prioritize effective adaptation strategies, and outline practical recommendations to strengthen the Metropolis's resilience to climate-related risks.

Figure 1: A framework of the CCRA goals





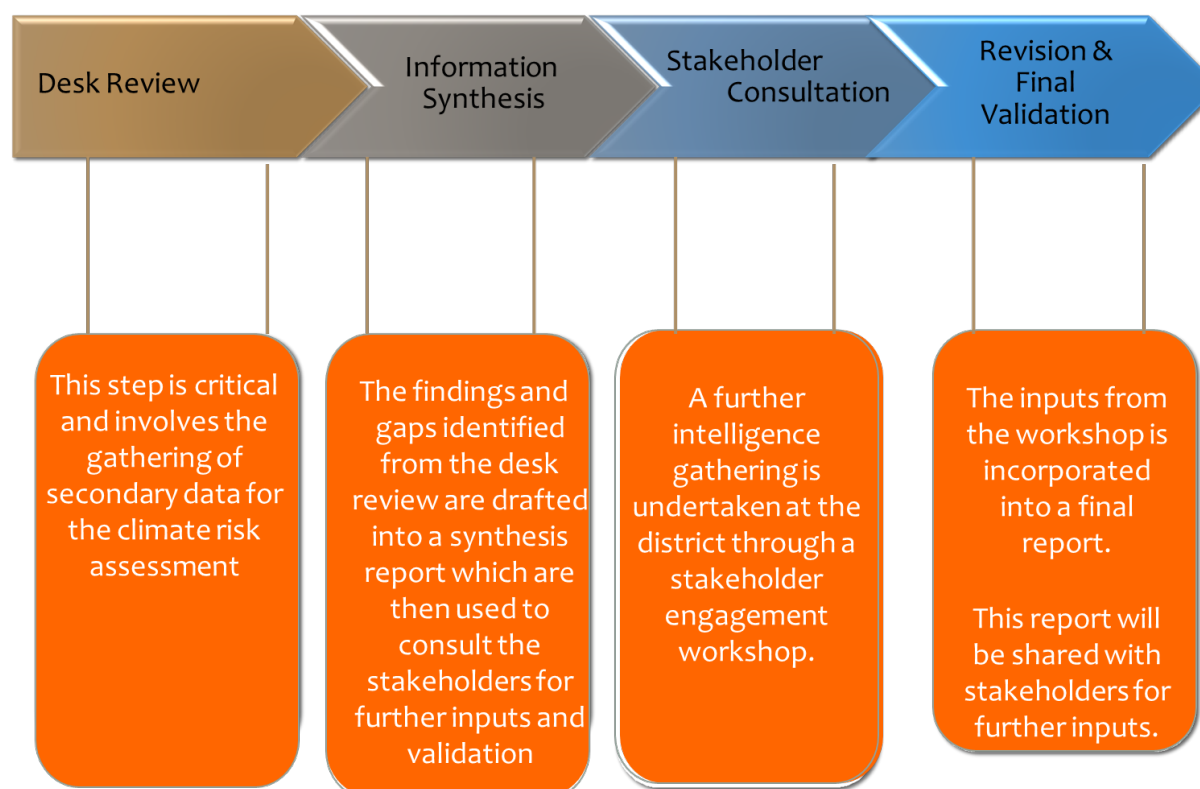
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Approach and Methodology

2.1 Approach

The assessment method for this Climate Change Risk Assessment for the Tema Metropolitan Assembly is a structured, sequential procedure that comprises the following steps:

Figure 2: Overall work approach for the Climate Change Risk Assessment for the Tema Metropolitan Assembly



- **Desk Review**

The desk review is the foundational phase of any risk or vulnerability assessment. For the Tema Metropolitan Vulnerability Assessment (VA), it serves as the cornerstone of the climate risk evaluation process. This phase involves gathering and analyzing secondary data to build a comprehensive understanding of the climate risks faced by the Metropolis. Secondary data sources include, academic research and case studies from relevant projects, government reports and policy documents and climate models and historical weather data.

The primary objective of the desk review is to compile a detailed and reliable dataset that underpins the evaluation of climate risks in Tema Metropolitan Area (TMA). Analysts conduct extensive research

and carefully synthesize data, cross-checking sources to ensure accuracy and to identify gaps or discrepancies for further investigation. This process yields critical insights into key climate-related factors, such as temperature fluctuations, rainfall variability, sea level rise and increased frequency and intensity of extreme weather events.

- **Information Synthesis**

Following the desk review, the next vital step is the information synthesis phase. During this phase, the extensive data collected is distilled into a cohesive and accessible report. This step is critical for translating raw data into actionable insights by highlighting key trends, significant findings, and any gaps identified during the desk review. The synthesis report serves multiple purposes. It condenses the comprehensive research into an easily understandable format, making the findings more accessible to a wide range of stakeholders. The report also provides a solid foundation for consultations with key stakeholders, including local communities, policymakers, scientists, and industry representatives.

Engaging stakeholders in this participatory process ensures that the climate risk assessment incorporates diverse perspectives and benefits from broad input and validation. This approach enhances the accuracy, relevance, and inclusivity of the assessment, refining its findings to better reflect the needs and priorities of all involved.

- **Stakeholder Consultation**

The stakeholder consultation phase is a critical component in making the climate risk assessment process inclusive and reflective of local realities. This step involves engaging a diverse group of stakeholders in a district-level workshop designed to gather valuable local insights and intelligence. The participants typically include representatives from local government, community organizations, businesses, academic institutions, and other relevant groups. Their involvement is essential, as they bring unique local knowledge, expertise, and experiences that can significantly enhance the assessment.

The consultation workshop provides a platform for open dialogue, where stakeholders can share their perspectives and help identify additional risks and opportunities that may not have been captured during the desk review or information synthesis phases. During the consultation, the preliminary findings from the synthesis report are presented, and stakeholders are encouraged to provide feedback. This participatory approach ensures that the climate risk assessment is not only based on scientific data but also aligned with local needs and realities.

Stakeholders can point out specific vulnerabilities, suggest mitigation strategies, and propose practical adaptation measures that may not have been apparent through secondary data alone. Moreover, involving stakeholders in the process fosters a sense of ownership and trust, increasing the likelihood that they will actively support and contribute to the successful implementation of the assessment's recommendations..

- **Revision and Final Validation**

This stage is about refining the assessment based on the inputs gathered during the stakeholder consultation and ensuring that the final report is accurate, comprehensive, and actionable. The inputs from the stakeholder workshop were meticulously reviewed and incorporated into the final report.

Once the revisions were made, the final report was validated by sharing the revised document with stakeholders for final review and approval. Their validation ensures that the report is not only technically sound but also aligned with the expectations and needs of the stakeholders. This step is crucial for building consensus and ensuring that the recommendations are feasible and supported by all involved parties.

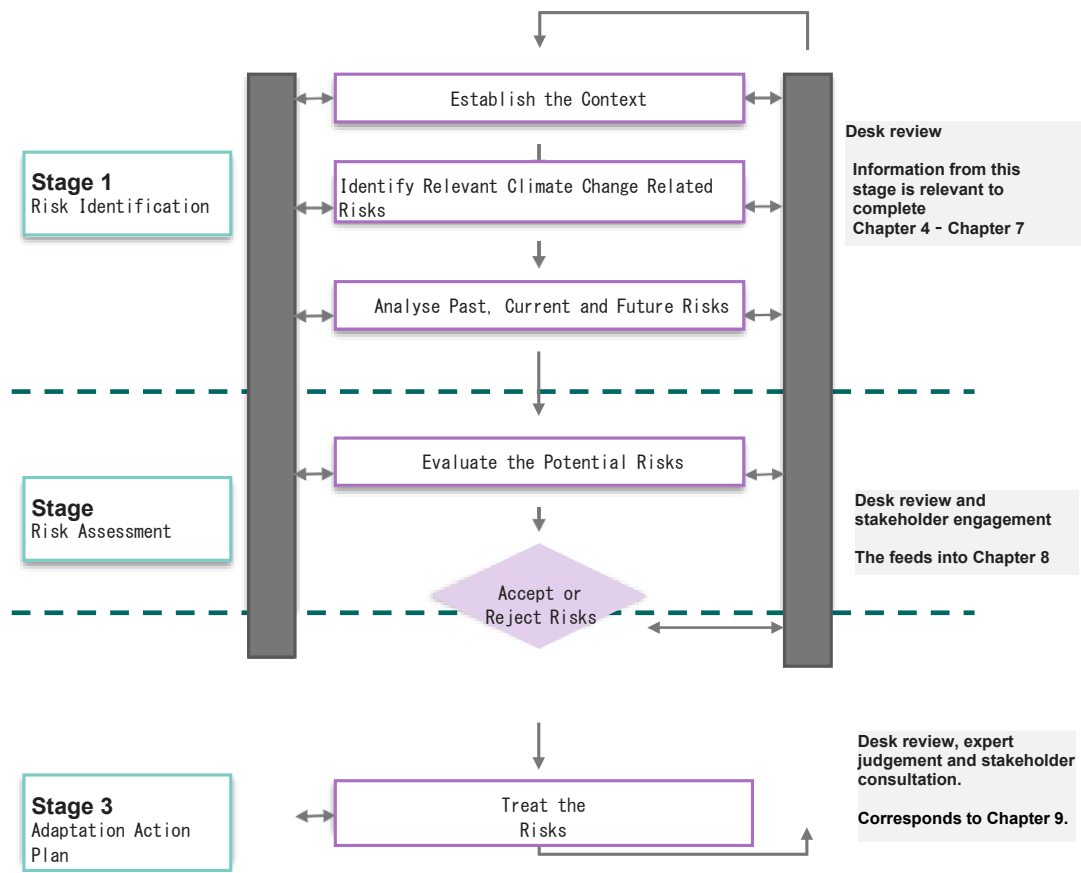
The final report serves as a strategic tool for policymakers, planners, and other stakeholders, providing a clear roadmap for addressing climate risks. By incorporating stakeholder inputs and undergoing rigorous validation, the final report becomes a credible and authoritative guide for climate risk management, setting the stage for effective implementation and long-term resilience building.

2.2 Methodology

The methodology for this Climate Change Risk Assessment, adapted from Norman et al. (2014), adopts a structured approach divided into three main phases, each with distinct focuses and activities (Figure 2):

- **Stage 1: Risk Identification** - The process began with establishing the context through an extensive desk review. This dual approach combined the collection of secondary data with insights from stakeholder engagements relevant to Tema's climate risk assessment. The literature review examined historical, current, and projected future risks, focusing on past climate variations' impacts and their future implications for the district. Stakeholders contributed to identifying risks through participatory discussions and mapping exercises, leveraging their expertise and local knowledge. This participatory process ensured a thorough evaluation, with risks either accepted for further consideration or rejected based on stakeholder consensus.
- **Stage 2: Risk Assessment** - This phase involved a detailed evaluation of the risks identified in the previous stage. Data and insights from the desk review were enriched by contributions from stakeholder engagements, which added diverse perspectives and local context. These engagements were critical to ensure the assessment was grounded in practical knowledge and expertise. Outputs from this phase included systematic documentation of risk severity, the financial implications of adaptation measures, and the district's capacity to manage these risks effectively.
- **Stage 3: Adaptation Action Plan** - The final stage focused on formulating an Adaptation Action Plan to reduce vulnerabilities and strengthen Tema's resilience to climate change impacts. This plan integrated findings from the desk review, expert analyses, and stakeholder consultations to propose strategic, actionable responses to the prioritized climate risks. The co-developed interventions outlined in the plan are designed to address key risks while supporting the district's broader climate adaptation objectives.

Figure 3: General overview of the risk assessment process.



Source: Adapted from (Norman, et al., 2014)



3



Overview of Tema Metropolis

The Tema Metropolis originated from the former Tema Municipality in 2007 through the enactment of Legislative Instrument (LI) 1929. Comprising three Sub-Metropolitan Councils—Tema West, Tema East, and Tema Central—the Metropolis spans an area of approximately 396km². Tema, situated within the Coastal Savannah Zone, serves as the capital of the Metropolis.

The geographical significance of the Tema Metropolis is underscored by the passage of the Greenwich Meridian (Longitude 0°) through its expanse, intersecting with the equator (Latitude 0°) in the Ghanaian waters of the Gulf of Guinea. Positioned 25 kilometres (16 mi) to the east of the capital city, Accra, within the Greater Accra region, Tema is not only the capital of the Tema Metropolitan District but has also evolved into the industrial nucleus of Ghana over the decades. The main Tema township has expanded and developed into the primary industrial hub of the country, contributing significantly to Ghana's industrial landscape.

3.1 Physical and environmental features

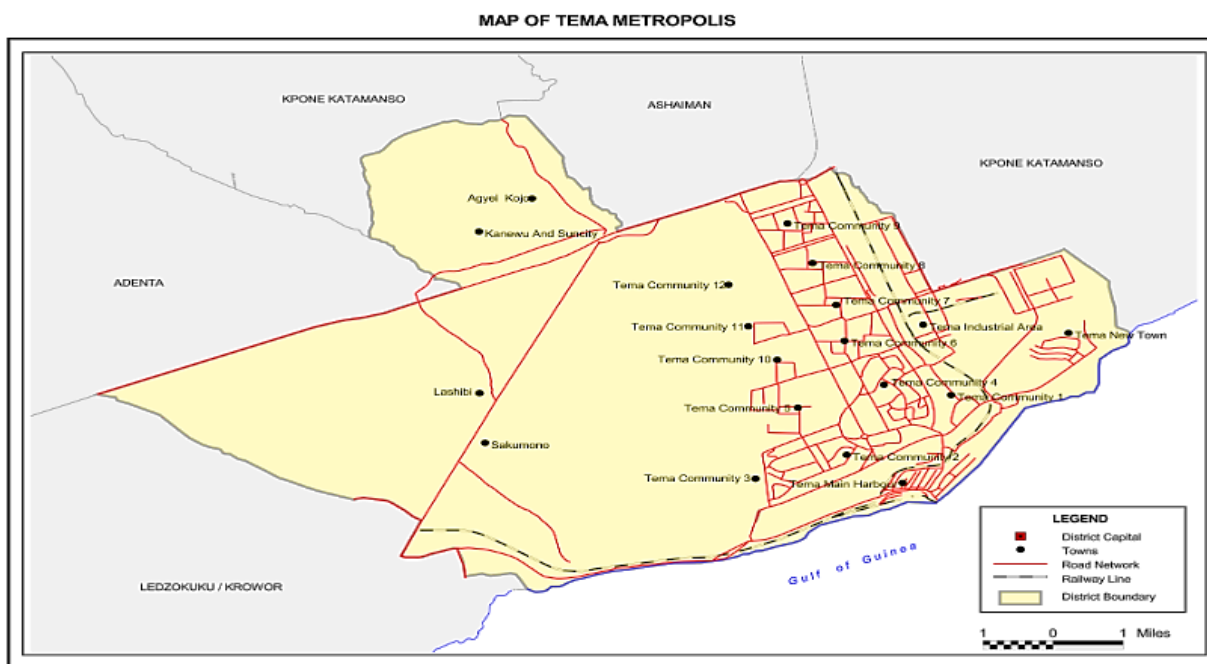
Tema's landscape is characterized by a generally flat topography. The Metropolis forms part of the coastal plains with an elevation of at most 35 meters above sea level. The predominantly flat nature of the land makes it prone to flooding. Nonetheless, the proximity of the Metropolis to the sea and its topography which also projects into the sea, makes it a natural endowment for a harbour. The Tema Harbour was thus constructed in 1957, making the Metropolis "the Eastern Gateway of Ghana"

Tema's defining physical features is its industrial landscape. The physical layout of Tema includes a well-developed transportation infrastructure. Tema was originally designed as an industrial community. The community has evolved into a city and Ghana's primary industrial centre. The road system facilitates the movement of goods to and from the industrial area and ensures efficient transportation within the city. The Tema Industrial Area, marked by a complex of factories, warehouses, and port facilities, stands as a testament to the city's pivotal role in fostering economic activities and industrialization in the region. This port serves as a key gateway for international trade, facilitating the import and export of goods.

Tema does not have any major rivers flowing directly through it. However, the Metropolis is characterized by numerous small streams. The streams in the Metropolis are seasonal which mostly flow through depressions into the lagoons (notable among them include Gao, Chemu and Sakumono lagoon) and subsequently into the sea (GSS, 2014). The lagoons in Tema deliver ecological services, including flood control, fresh water, fisheries and preservation of species. For instance, the Sakumono lagoon which borders Tema was gazetted as a Ramsar site in 1992 because of its ecological significance. The lagoon covers an area 1,340 hectares. However, during the dry season, large sections of the lagoon experience dry up, leading to hyper-saline conditions. To address this, a small permanent connection to the sea has been established through an open sluice, strategically constructed to mitigate coastal road flooding. The Chemu Lagoon is another major lagoon situated to the East of Tema. The lagoon is presumed to be Tema's most contaminated body of water (Kyeremeh et al., 2022) due to its close proximity to industries.

The Tema Metropolis has its main source of water supply from the Kpong water works. The metropolis also has its own centralised sewage system. The Tema Central Sewerage System was constructed during the planning and development of the Tema Township. The system consists of a network of pipes designed to transport sewerage to three pumping stations and two ejector stations. Subsequently, these pumping and ejector stations facilitate the movement of sewerage through a detention basin and ultimately discharge it into the sea.

Figure 4: Map of Tema Metropolitan Assembly



Source: Ghana Statistical Service GIS, 2010 Population & Housing Census

3.2 Climate and Vegetation

The Tema lies within the coastal savanna zone. The metropolis is thus characterized by a blend of coastal and savanna landscapes which influences the city's climate, vegetation, and overall ecological dynamics. The proximity to the Gulf of Guinea contributes to the moderation of temperatures and the presence of distinct coastal features.

The vegetation in the Metropolis is characterised by a mix of shrub land, grassland and few patches of semi-deciduous forests. The soils within the Tema Metropolis consist of a mixture of sand, clay, humus, gravel, and stone. The sandy and humus-rich composition of the soil facilitates the cultivation of vegetables. On the other hand, the clayey nature, while suitable for brick production, may pose challenges for general construction activities. Underlying the Metropolis are Precambrian rocks of the Dahomeyan formation, predominantly metamorphic rocks such as granite, gneiss, and schist, likely derived from sedimentary layers. These rock formations undergo weathering or decomposition at the surface, with a thickness not exceeding 12 meters in the area (GSS, 2014)

The coastal Savannah agroecological zone in which Tema metropolis lies, experiences two distinct rainfall seasons: the major season spans from April to July, peaking in June, while the minor season occurs from September to early November, with the highest rainfall recorded in October. During these periods, the region is affected by the warm moist South West (SW) monsoon winds. The dry season commences in late November

and extends until March. During this period, the region is occasionally affected by the dry North East (NE) Trade winds. Despite having a bimodal rainfall pattern experiencing 151.69 rainy days, amounting to 41.56% of the time, this zone receives the least amount of precipitation among the country's six agroecological zones. The mean annual rainfall is 800mm with rainfall ranges from 600mm to 1000mm.

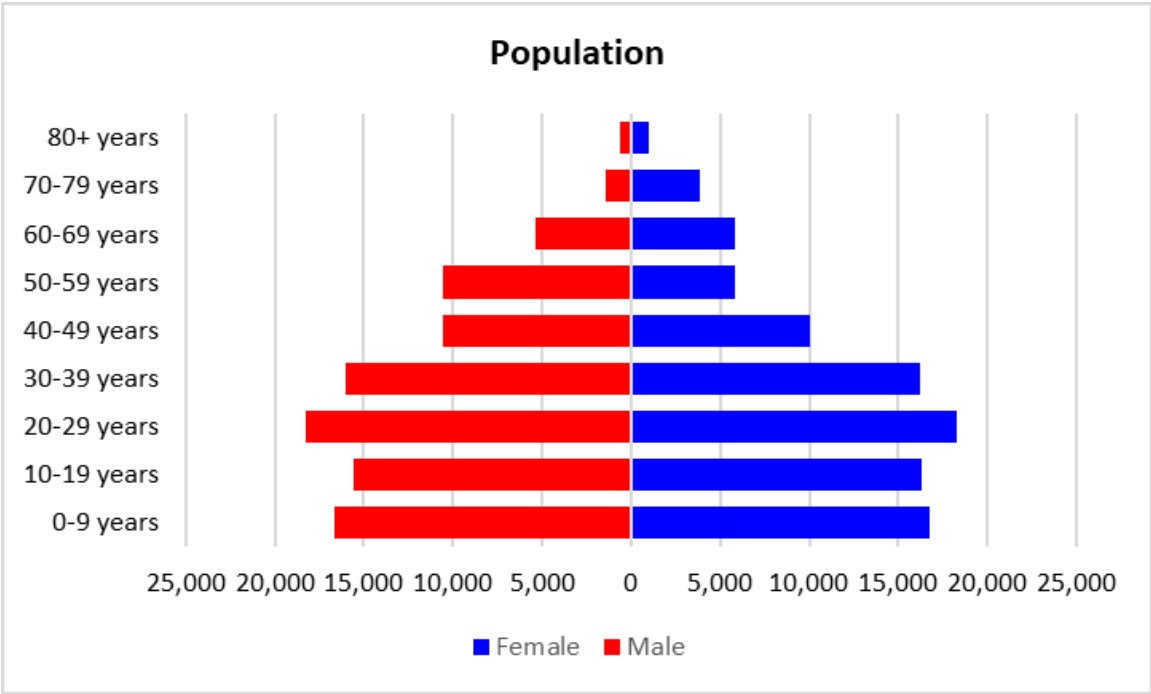
The average monthly temperature fluctuates around 27 °C, with a minimum of 24.7 °C in August and a maximum of 32.7 °C in March. The average annual percentage of humidity is 83%. With December being noted as the sunniest month with an average of 242 hours of sunshine.

3.3 Demographics

According to the 2020 Population and Housing Census (GSS, 2021), the total population of the Tema Metropolitan Assembly was 177,924 of which 50.8% are female. The Metropolis has no rural settlements. With a population density of 5,169.7 (persons per square Km). The report notes that the average household size is 3.2 with an estimated 55,037.

The population distribution in the Tema Metropolitan area indicates that the age group 25-29 has the highest representation, accounting for 11.4 percent. In contrast, the age groups 90-94 and 95-99 have the smallest populations, each representing 0.1 percent. According to GSS (2011), the total age dependency ratio for Tema Metropolis for is 50 and it is 51.3 for males and 48.7 for females. Thus, for every 100 people in the economically active group (15-64 years of age) there are 50 persons who are dependent on them. On average, there is a higher proportion of females than males in the metropolitan area, with a male-female ratio of 92:100. However, males within the ages of 20-29 years are the highest populated group. Whilst females within the same age group are the most populated female group. Indicating the prominence of youth in the population of TMA.

Figure 5: Population Pyramid of TMA



3.4 Administration and governance

The Tema Metropolitan Assembly (TMA) was established on November 1, 2007, under the decentralization system mandated by the Local Government Act 462 of 1993 and Local Government Legislative Instrument LI 1929, to control over the day-to-day operations of the city. The Assembly is mandated by the constitution to formulate bye-laws and policies in the district. The General Assembly is the main body of the Assembly responsible for formulating bye-laws and policies in the district. It consisting of fifty members. This board comprises the Metropolitan Chief Executive, forty-six Assembly Members (thirty-two elected and fourteen appointed by the President of Ghana in consultation with traditional authorities and opinion leaders), and the three Members of Parliament representing the Tema West, Tema East, and Tema Central constituencies who do not have voting rights.

The Mayor of Tema oversees the day-to-day executive functions of the Metropolitan Assembly. The Mayor heads various Assembly departments, and serves as the chief representative of the Central Government in the Metropolis. Administratively, the Executive Committee, responsible for coordinating sub-committee plans and programs, plays a vital role in implementing Assembly resolutions and overseeing administrative functions in collaboration with the Chief Executive's office. The Executive Committee is comprised of various sub-committees, including Development Planning, Social Services, Works, Education, Finance & Administration, Environmental Management, and Revenue Mobilization.

3.5 Economy of Tema Metropolitan Assembly

The industrial sector in Tema is robust, hosting over 500 industries engaged in the production of a wide array of goods, including chemicals, textiles, consumer electronics, machinery, steel, and refined petroleum products. Notably, the Tema Industrial Area is a focal point for various manufacturing activities, contributing significantly to the city's industrial prominence.

The Government of Ghana acquired a large tract of land designated as a "Free Zones Area" near the port for the production of goods, 70% of which are expected to be export and the remaining for local consumption. Tema's Free Zones Enclave has been instrumental in attracting foreign direct investment and promoting export-oriented businesses. The enclave offers incentives to companies, fostering economic growth and diversification.

The municipality also has fishing as a major agricultural and economic activity because of its proximity to the sea and other water sources. This is supported by the presence of the Tema Fishing Harbour.

Figure 6: Tema Fishing Harbour (Left). Valco Roundabout, Tema Industrial Area (Right)



Source: Aerial View of Tema Fishing Harbor | Ghana's Largest Fishing Port.

Source: Valco Roundabout | Tema, Ghana



4



Climate Change Vulnerability of the Tema Metropolitan Assembly

In recent years, Ghana has adopted a multifaceted approach to climate change policy, focusing on reducing greenhouse gas emissions and building resilience to climate impacts. The Ghana National Climate Change Policy provides a framework to tackle challenges such as rising temperatures, unpredictable rainfall, and sea-level rise. It emphasizes the integration of climate change considerations into national development plans, targeting adaptation, social development, and mitigation in key sectors like agriculture, food security, disaster preparedness, natural resource management, and infrastructure.

Key components of Ghana's climate change strategy include:

Ghana's NDC outlines commitments to reduce greenhouse gas emissions and adapt to climate change within priority areas such as mass transit, infrastructure, land use, food production, energy, and forest and water resource management. The country aims to cut emissions by 64 million tons of CO₂ equivalent by 2030, contingent on international support and cooperation.

Ghana is in the process of developing a NAP to enhance resilience against climate impacts. Using climate projections extending to 2080, the plan integrates responses to climate change with global challenges like the COVID-19 pandemic. It prioritizes cross-sectoral planning and coordinated efforts to address future vulnerabilities.

Implementing the measures outlined in the NDC will require substantial funding, estimated between \$9.3 billion and \$15.5 billion for the period 2020–2030. Ghana expects to secure significant international funding and emphasizes the role of innovative financial mechanisms and partnerships with the private sector to achieve these goals. Despite progress, Ghana faces challenges in executing climate policies, including limited political commitment, inadequate technical capacity, and weak corporate compliance. Establishing a robust climate change regulatory body is essential for policy enforcement. Additionally, outsourcing technical implementation to private entities under regulatory oversight could improve efficiency.

Ghana's legislative process for climate policy involves multiple stages, from drafting by the Parliamentary Counsel to approval by various government bodies, ultimately leading to the enactment of laws that support climate action.

4.1 Defining Climate Change Risk and Vulnerability

The concept of climate change risk and vulnerability is understood differently by various international organizations, each contributing unique perspectives to these core elements of climate science.

The IPCC defines climate change risk as the potential for adverse consequences or damage resulting from the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. This interpretation incorporates the likelihood and magnitude of harmful outcomes, factoring in the severity of hazards, conditions of vulnerability that can amplify or reduce risks, and the extent of exposure (IPCC, 2014).

The UNFCCC describes climate change risk as the probability and severity of adverse effects resulting from climate events on human and natural systems. Vulnerability, according to the UNFCCC, involves the character, magnitude, and rate of climate change experienced by systems, as well as their sensitivity and adaptive capacity (IPCC AR4, 2007).

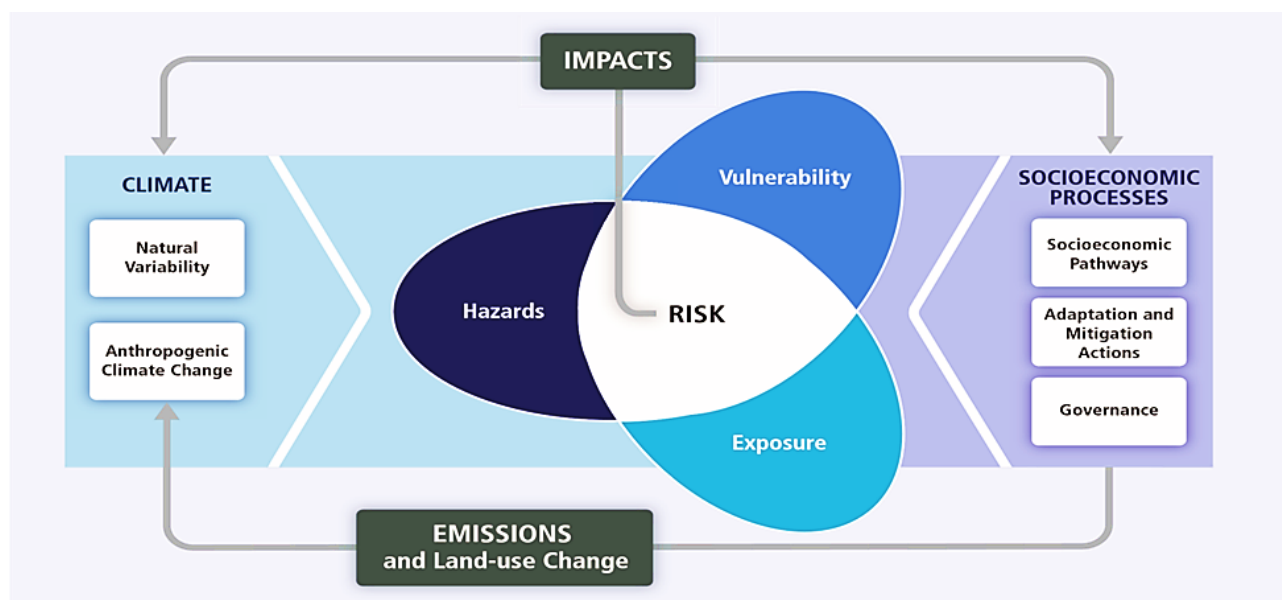
The WHO emphasizes the likelihood of health impacts stemming from climate-related hazards such as heatwaves, floods, and disease outbreaks. From this perspective, vulnerability pertains to the predisposition of populations to these health risks, shaped by factors including age, socioeconomic status, pre-existing health conditions, and access to healthcare services (WHO, 2021).

The UNDRR views climate change risk as a combination of the frequency and intensity of climate hazards and the level of human exposure and vulnerability. Vulnerability, in this context, is shaped by physical, social, economic, and environmental factors that increase a community's susceptibility to these hazards (UNDRR, 2022).

The World Bank considers both transition risks, related to the economic shifts required for a low-carbon transition, and physical risks, which stem directly from climate change impacts. These risks carry profound financial and socioeconomic implications. Vulnerability is framed in terms of economic resilience, reflecting the susceptibility of economies to external shocks driven by climate variability and change (Hallegatte, 2014).

Each of the organizations emphasize distinct aspects of climate change risk and vulnerability, focusing on areas such as health, economic systems, disaster preparedness, and policy development. These perspectives collectively provide a broad framework for assessing the potential impacts of climate change, including its implications for the Tema Metropolitan Assembly. Resources like the IPCC Special Report on Managing the Risks of Extreme Events and Disasters (SREX) and WGII AR5 offer valuable guidance for understanding these challenges (Figure 4).

Figure 7: Risk assessment framework for evaluating climate change risks



Source: IPCC's AR 5 framework of risk assessment (Adapted from Field et al. 2014)

This framework integrates definitions that emphasize common aspects such as the potential consequences, susceptibility, and the ability to address climate change impacts. Risk and vulnerability collectively underpin assessments by the IPCC and affiliated bodies to measure and understand the potential effects of climate

change. These assessments inform the formulation of strategies for adaptation and mitigation, focused on mitigating risks and bolstering the resilience of systems against climate change impacts. Specifically for the Tema Metropolitan Assembly, this framework fulfills several key objectives:

1. **Identifying Potential Impacts:** Understanding how climate change could affect local communities, economies, and ecosystems within Tema.
2. **Assessing Vulnerability:** Evaluating which areas or populations within Tema are most susceptible to the impacts of climate change.
3. **Evaluating Response Capacity:** Determining the ability of the Metropolitan assembly to respond to and recover from climate-related events.
4. **Guiding Policy and Planning:** Informing the creation of policies and plans that aim to reduce risk and enhance resilience, tailored to the unique needs and capacities of Tema.

In the context of the Tema Metropolitan Assembly, the climate components include natural variability and anthropogenic climate change. Tema, like many regions, experiences natural climate fluctuations that can lead to variability in rainfall, temperature, and seasonal patterns. However, human activities such as deforestation, bush burning, and agricultural expansion significantly contribute to climate change, exacerbating the frequency and intensity of extreme weather events such as floods, droughts, and heatwaves.

The **‘Hazards’** represent these physical manifestations of climate change. For Tema, key hazards include erratic rainfall patterns leading to flooding, prolonged dry spells causing drought, and extreme temperatures affecting agricultural productivity and water availability. These hazards pose significant risks to the local population, ecosystems, and infrastructure.

‘Exposure’ in Tema refers to the presence of people, assets, and ecosystems in areas prone to climate hazards. The Metropolitan assembly must consider how rural settlements, critical infrastructure such as health centers and schools, and agricultural lands are exposed to these risks. For example, farming communities near water bodies are particularly vulnerable to flooding, while those reliant on rain-fed agriculture face risks from drought and heat stress.

‘Vulnerability’ in Tema is shaped by social, economic, and environmental factors. High poverty levels, limited access to healthcare and education, inadequate infrastructure, and a heavy reliance on subsistence farming heighten the community’s susceptibility to climate hazards. Additionally, local capacity for adaptation—such as access to resources, technology, and skills to implement resilient infrastructure or diversify livelihoods—plays a critical role in determining vulnerability.

‘Socioeconomic processes’ further influence climate risk in Tema. Socioeconomic pathways, including population growth and land-use practices, shape the scale and nature of exposure and vulnerability. Actions taken by the Metropolitan assembly to address these, such as implementing early warning systems, engaging communities in disaster preparedness, and promoting sustainable agricultural practices, are vital for reducing climate risks.

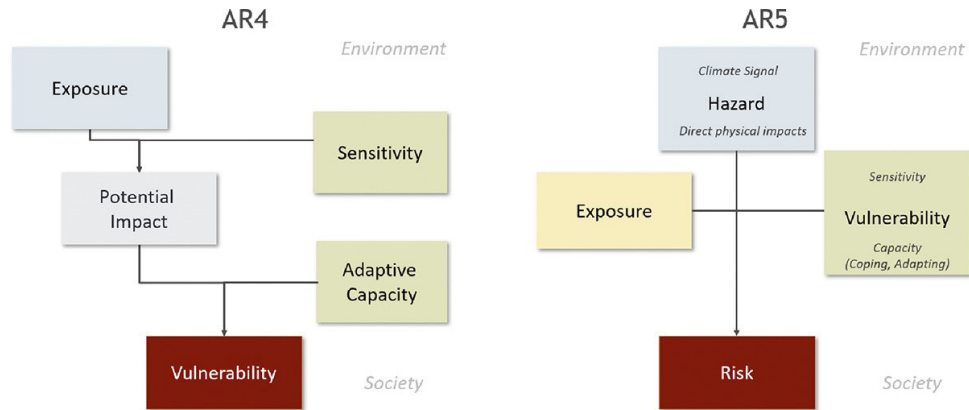
‘Emissions and land-use change’ are also pivotal in this framework. Local activities such as deforestation and charcoal production contribute to greenhouse gas emissions, while practices like reforestation and sustainable farming can mitigate emissions and enhance local climate resilience.

The **‘Risk’** is then a product of these hazards interacting with the exposed and vulnerable systems within the Metropolis. It represents the likelihood of adverse outcomes, including threats to human life and well-being, damage to infrastructure and property, and the degradation of ecosystems and biodiversity.

The **‘Impacts’** of climate change are evident across natural and human systems in Tema. These impacts are shaped by the intersection of climate risks with ‘Socio-economic Processes,’ including local development trends, community adaptive practices, and the effectiveness of governance structures in managing and responding to these risks. Effective policies and coordinated actions at the Metropolitan level are crucial to reducing these impacts and building resilience.

It is crucial to recognize the shift in how vulnerability and risk are defined between the Fourth Assessment Report (AR4) and the Fifth Assessment Report (AR5), as illustrated in Figure 6. In the context of climate change, vulnerability to potential impacts is determined by sensitivity and adaptive capacity. Current vulnerability, however, is shaped by a combination of socioeconomic factors—such as dependence on high-risk sectors like agriculture—and the institutional capacity to manage and mitigate escalating climate-related risks, including floods and droughts.

Figure 8: Change in conceptual approach to climate change risk assessment



Source: From Zebisch *et al.* (2017)

Source: Zebisch *et al.*, 2021

4.2 Current Vulnerability – Sensitivity and Adaptive Capacity

The current climate change vulnerability for TMA is a measure of how likely the Metropolis and its people are to be adversely affected by the impacts of climate change, such as rising temperatures, changing rainfall patterns, extreme weather events, and sea level rise. The vulnerability of Tema depends on the exposure, sensitivity, and adaptive capacity of the metropolis and its sectors or systems, such as infrastructure, health, agriculture, and environment

4.2.1 Economic Vulnerability

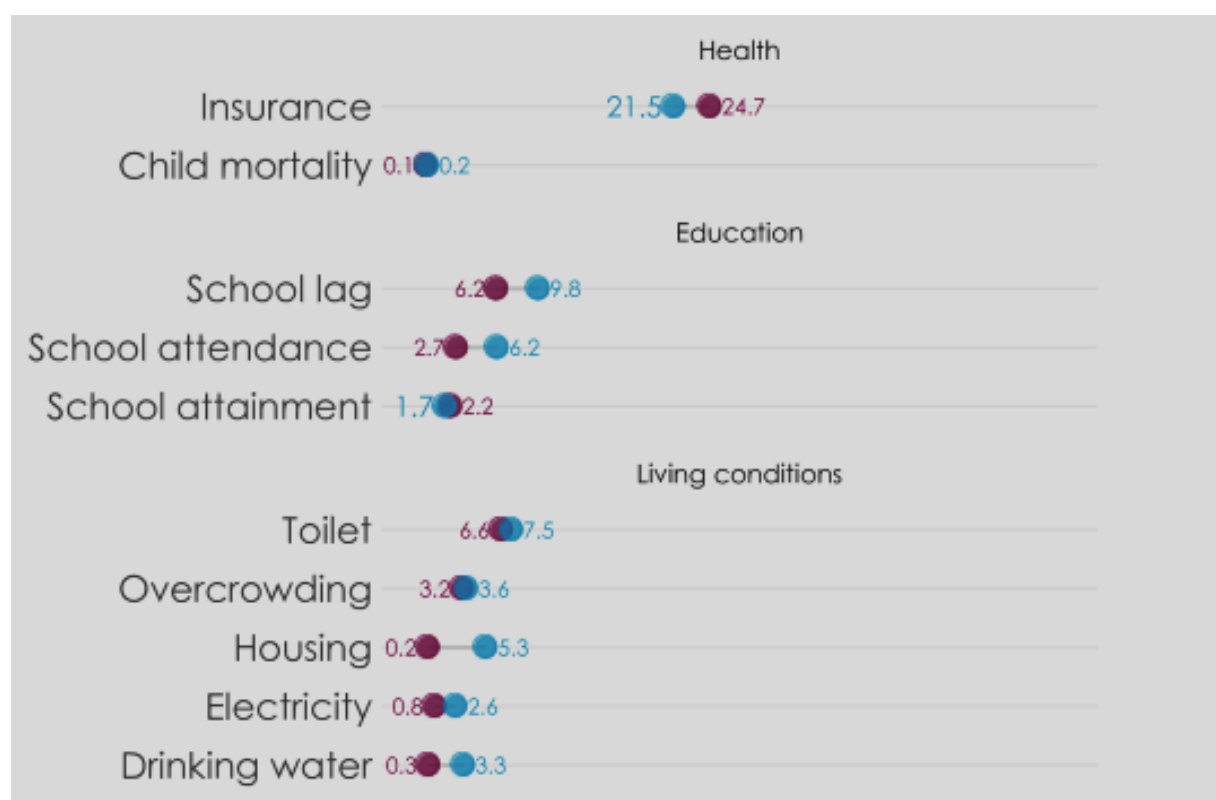
As the Tema Metropolis continues to expand, the existing socioeconomic infrastructure faces escalating demands to effectively accommodate both current and incoming residents.

City expansion significantly impacts urban agriculture. For instance, in a study conducted to assess the concerns of vegetable farmers by the Tema Motorway, whose farms are likely to be destroyed with the expansion of roads, (Sedegah *et al.*, 2023) reports that the anticipated expansion project of the highway has instilled various concerns among farmers, manifesting as apprehensions about the potential

disruption of their livelihoods and income due to potential damage to crops and land loss. As well, the lack of information regarding a compensation package to mitigate the impact of their displacement from their primary source of livelihood further exacerbates these fears among the farmers. the potential loss of livelihoods and income poses livelihood vulnerability challenges to farmers. According Amoah, in Ghana's coastal communities including Tema, where a significant number of individuals have livelihoods related to fishing, the impact of socioeconomic shocks is exacerbated due to the limited availability of state-led social protection. Economic vulnerabilities shocks such as COVID-19 can exacerbate structural inequality leading to reduced market demands, income loss, and difficulties in meeting household needs.

The Multidimension Poverty Report factsheet of Tema Metropolis notes that 11.6% of the population of Tema live in multidimensional poverty. That is, 11.6% of households in the metropolis are deprived along the three dimensions of monetary poverty, education, and basic infrastructure services. The report revealed that the population in Tema are deprived in the areas of improved toilet facilities (66%), lack of health insurance coverage (65.6%), and overcrowding (35.4%). The metropolitan's depravation. The report further adds that the average intensity of poverty is 43.8 per cent. Tema is ranked 36th out of the 261 districts in Ghana's multidimensional poor households report. The report noted that among the prevailing factors, unemployment and poor living conditions contribute to multidimensional poverty in TMA.

Figure 9: Contributions to Multidimensional Poverty



Source: Tema Metropolitan Area (TMA) District Multidimensional Poverty

The (UNDP, 2021) 2020 SDG report also highlights that the prevalence of slums is notable in urban areas like Tema. These slums are created due to the large influx of migrants from both urban and rural areas in Ghana for livelihood opportunities. The slums are characterised by deplorable housing conditions and poor access to basic services. However, due to lack of suitable employment opportunities and social support systems, residents contend to access the non-available social systems present in slums in cities.

The Ghana statistical Service states that the level of unemployment is 14.3% and the economy is largely informal with 60% employed in the private informal sector. Informal sector workers may face challenges in accessing credit and financial services, hindering their ability to invest or cope with climate impact.

4.2.2 Physical Vulnerability

According to (William et al., 2017) because coastal conditions in many parts of the region are poorly understood, knowledge on which population groups are at the most risk is less known, particularly in the Greater Accra Metropolitan Area (GAMA, coastal towns situated along the African coast are particularly susceptible to the impacts of climate change, including flooding and the rising sea levels. The low lying terrain of Tema makes it very susceptible to flooding (GSS, 2014). Periodic flooding severely hampers livelihoods. While the lack of proper drainage significantly influences the occurring of floods during heavy rainfall in Tema. The Sakumo Ramsar Site is rated as the third most important for seashore birds on the Ghana's coast. The Wildlife Society states that over 70 species of waterbirds have been recorded at the Sakumo site with an estimated population of some 30,000 birds. Mahtab-Uz-Zaman et al. (2022) and Opoku (2013) wetlands provide unique habitats for various types of fauna and flora. Consequently, wetlands have gained importance worldwide for conservation purposes and are designated as Ramsar Sites. However, urbanisation and subsequent population explosion has left some of our urban wetlands in deplorable and degraded conditions. The Sakumo Wetland and its catchment is one of such areas which has not been spared. This paper sought to assess the level of encroachment within the Sakumo Ramsar Site, in the Accra and Tema Metropolis (Ghana notes that anthropogenic factors such as the encroachment of the Sakumono Ramsar site by real estate developers often leads to the flood of communities in the Tema Metropolis. The gradual destruction of the Ramsar site for real estate also poses real risks to the extinction of biodiversity which depend on the ecosystem service.

The flooding in the area poses a threat to income and livelihood security. The destruction of homes, offices, farming sites pose risks to the properties and livelihoods of inhabitants. Damage to roads caused by heavy roads often threaten the safety of residents who use the Tema motorway.

The industrial growth of Tema also poses a threat to its environment in terms of waste management of industrial effluents. Abubakari et al. (2016) reveals that a substantial percentage of pollution of streams and rivers arises from the discharge of industrial effluents into surface water bodies. The study focused on evaluating the impact of industrial effluent on the quality of the Onukpawahe stream, in Tema Metropolis. The findings of the study confirmed that the stream has been contaminated by the industrial activities, severely compromising its overall quality. As well, the emissions from industries pose threat to the air quality and respiratory conditions of residents. A UNEP report (UNEP, 2015.) notes that in 2015, there were 17 tonnes of black carbon emissions from the Port of Tema as well as approximately 23 tonnes of particulate matter with diameters smaller than 10 microns and 23 tonnes of particulate matter with diameters smaller than 2.5 microns.

Figure 10: Flood displaces household



Source: [Modern Ghana Online News, 2022](#)

4.2.3 Social Vulnerability and Adaptive Capacity

As mentioned earlier, the expansion of metropolis such as Tema, results in the attraction of many young people to perceived economic opportunities. The mass migration of youth and active economic population without an expansion and availability of social amenities expose the immigrants to several vulnerable population. The Multidimensional Poverty report notes that Tema is deprived of improved toilet facilities (66%) and lack of health insurance coverage (65.6%) which are above the national average. The poor housing and income insecurity of immigrants and minorities in the metropolis exposes them climate induced diseases and the risk of other hospitable infections. In a study of the distribution of risk factors in Greater Accra, (Kawaguchi et al., 2022) identified Tema as a malaria hotspot and found that the malaria infections in the hotspots were positively associated with monthly rainfall and negatively correlated with minimum temperature, calling for a strengthened control and prevention in malaria hotspots.

Alhassan, (2014) observed that the supply-demand gap of potable water in rapidly growing urban cities in developing countries has become a major challenge. The estimated daily demand of 150 million gallons in the Accra-Tema Metropolitan Area (ATMA) region of Ghana far outweighs the daily supply of 94 million gallons. The existing water supply and sanitation infrastructure in Tema may not be adequately equipped to accommodate the burgeoning population. This leads to overburdened facilities, compromising the quality and accessibility of clean water. Climate induced migrants often settle in informal settlements with limited access to basic amenities, including clean water. These vulnerable communities face heightened challenges in securing clean drinking water, perpetuating health risks and inequalities



5



Observed Climate Trends at Tema Metropolitan Assembly

5.1 Local Level Trends

Historical temperature data observed in Tema revealed trend in mean annual temperatures and rainfall patterns. Asare-Nuamah and Botchway (2019) explains that the temperature in this zone remains relatively consistent, characterized by a low coefficient of variation. The months of February, March, and April were observed as the hottest, with mean temperatures of 29.4 °C, 29.1 °C, and 29.3 °C, respectively. A study by (Teye & Owusu, 2015) reports that the mean annual temperature in the coastal savannah zone, encompassing Tema, has witnessed a 1.0°C increase since the 1960s, equivalent to an average rise of 0.210°C per decade. Throughout the period of 1965 to 2015, the mean maximum temperature fluctuated between 29°C and 30.5°C, exhibiting a 0.02 °C increase. Meanwhile, the mean minimum temperature ranged between 23.8 °C and 25.3°C, experiencing a 0.03°C rise from 1965 to 2015. Notably, the highest recorded mean minimum temperature was 25.6 °C in 2010, while the lowest was 23.2 °C in 1967. Projections from the study anticipate future mean temperature increases of 0.60°C, 2.00°C, and 3.90°C for the years 2020, 2050, and 2080, respectively. These temperature elevations are poised to intensify water stress, jeopardize food security, and contribute to the displacement of vulnerable communities. Nonetheless, (Wemegah et al., 2020) suggests that Even though the rate of warming is faster in Accra than Tema, the night time temperatures at Tema are warmer than those of Accra suggesting the existence of nocturnal urban heat island at Tema.

According (Teye & Owusu, 2015), the average rainfall for Tema was recorded at 800 mm per year with negligible variation in monthly averages in the major rain season but high variations in the minor rain season. However, major season rains are dispersed and inconsistent, with a high standard deviation of 241.6 mm. (Asare-Nuamah & Botchway, 2019a; Braimah et al., 2022). The highest and lowest recorded rainfall between 1961 and 2015 occurred in the 1960s and 1970s, with 1720.5 mm in 1968 and 329.4 mm in 1977. The study notes that the 1980s experienced periods of drought, notably in 1983 and 1986, with rainfall amounts of 330.5 mm and 368.0 mm, respectively. In the 1990s, there was an increase in rainfall from 1995 to 1997, peaking at 1294.8 mm in 1997, followed by a significant decrease to 334.9 mm in 1998. The 2000s saw both high and low rainfall amounts, peaking in 2007 (1043.0 mm), 2010 (946.3 mm), and 2014 (1064.6 mm), and reaching lows in 2004 (407.0 mm) and 2013 (484.6 mm). (Asare-Nuamah & Botchway, 2019b) further adds that monthly rainfall in the coastal savannah is highly unreliable, with coefficients of variation greater than 0.5 mm, except for rainfall in May.

Braimah et al. 2022) highlights that southern Ghana exhibits the lowest mean rainfall of 125.2 mm and the lowest maximum rainfall of 373.5 mm. The study also found that also Tema showed to have a symmetrical number of rain days (skewness = -0.1), with the lowest mean rainy days (15.6 days) and the lowest maximum of 26 rain days, having no outliers (kurtosis of -0.6), and showing 37% variability. As a tropical region, Tema maintains high humidity levels throughout the year, ranging from 73% to 85%.

Figure 11: Average temperature in Tema, TMA

Average temperature Tema, Ghana

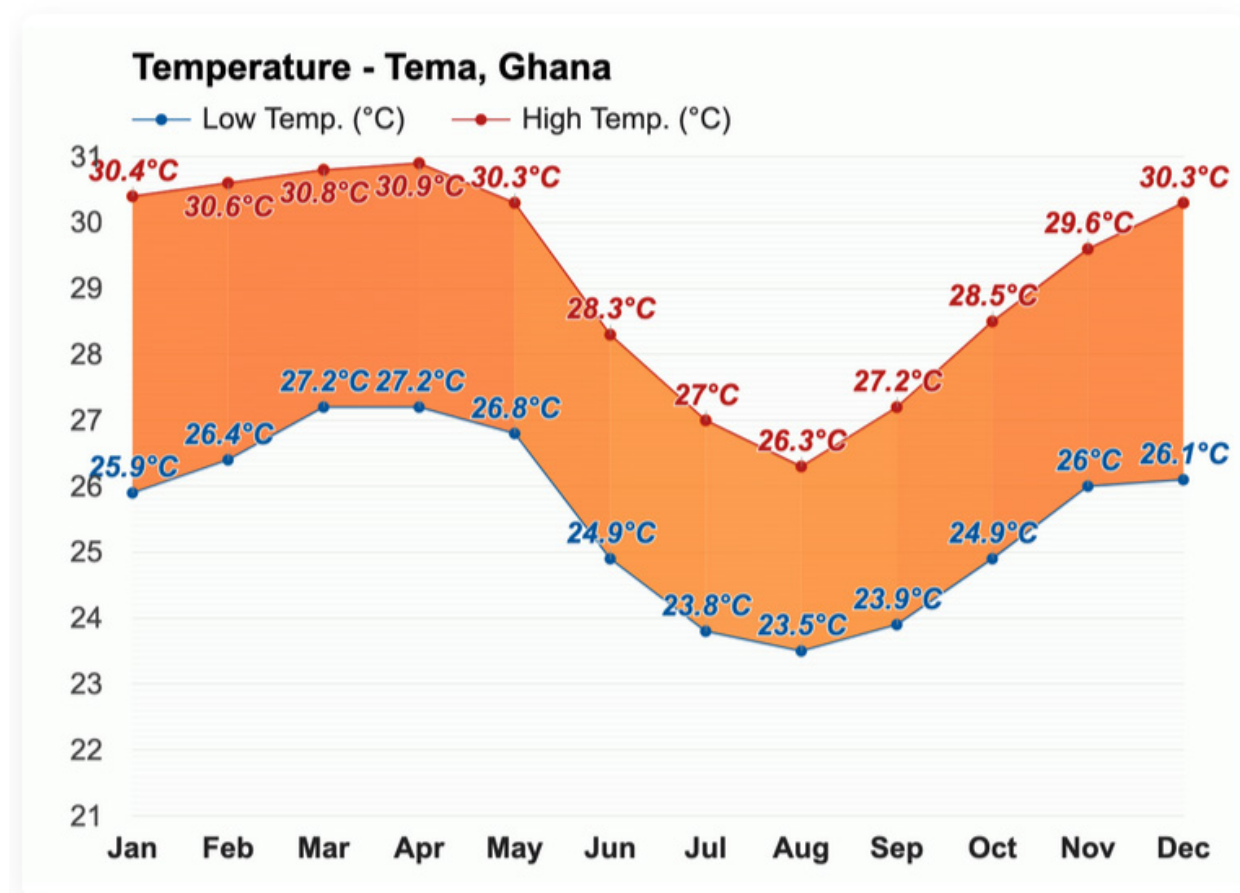
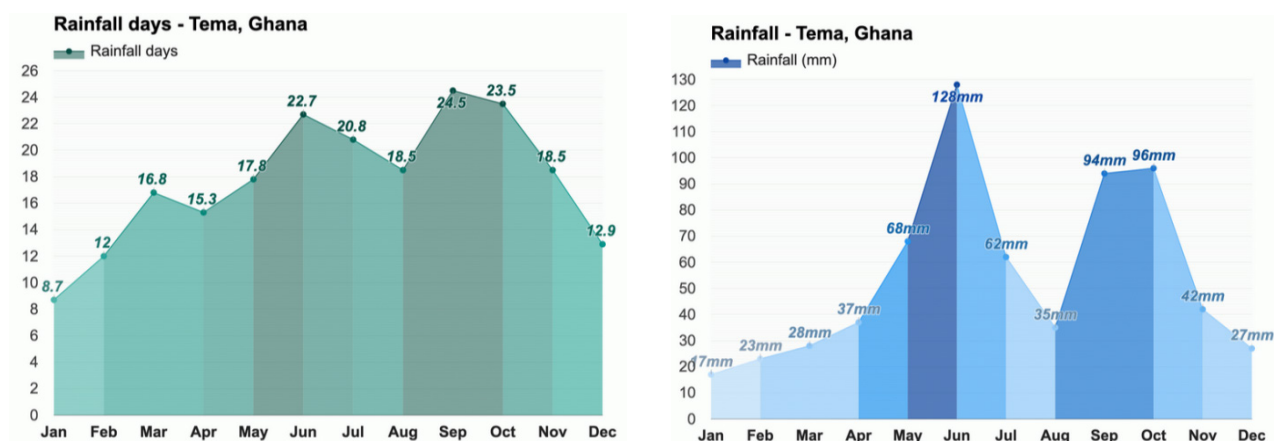


Figure 12: Average Rainfall (Left). Average rainfall days per month (Right)



Source: Weather Atlas

5.2 Observed Natural Hazard and Extreme Events

According to (Yankson et al., 2017) because coastal conditions in many parts of the region are poorly understood, knowledge on which population groups are at the most risk is less known, particularly in the Greater Accra Metropolitan Area (GAMA), the historical trend and climate projections show an increasing pattern of exposure to flood hazard. Tema has experienced several episodes of flooding. Tema's environmental landscape makes

it susceptibility to extreme weather events. The region has experienced erratic rainfall patterns, as highlighted by Braimah et al. (2022). Heavy rainfalls often lead to the flooding the metropolis' lagoons and Ramsar sites which have been encroached.

Also, the enlargement of the city has led to the increase the slum areas, characterized by densely populated and often informal settlements. These areas face increased vulnerability to fire outbreaks due to factors such as poor electrical wiring, inadequate infrastructure, lack of proper housing, and limited access to firefighting resources. Also, the metropolis has experienced several fire outbreaks in both residential and industrial areas. The impact of fire incidents can be devastating, leading to loss of lives, displacement of communities, and further exacerbation of socio-economic challenges

Table 1: Existing and past climate change events/occurrences at the local area

Date	Hazardous Event	Location	Impact	Reference
Oct-19	Flood (torrential rains)	Accra Tema	Floods cause gridlock on Accra-Tema motorway	https://www.ghanaweb.com/GhanaHomePage/election2008/Floods-cause-gridlock-on-Accra-Tema-motorway-794083?video=1&jwsourc=cl
May-23	Flood	Kpone Barrier portion of the main Tema-Aflao N1 road	Floods hit eastern Accra after morning downpour	https://www.myjoyonline.com/floods-hit-eastern-accra-after-morning-downpour/
Sep-23	Flood (torrential rains)	Areas like the Tema Motorway, Kwame Nkrumah Interchange, Kaneshie, North Kaneshie, Alajo, Adabraka, Accra Central, Tema, Tema station-Accra, Osu, and others were all heavily affected after close to an hour of rainfall.	Accra floods again, leaving homes and businesses submerged	https://citinewsroom.com/2023/09/accra-floods-again-leaving-homes-and-businesses-submerged/
Jun-22	Flood (torrential rains)	Accra Tema	Tema Station Junction flooded, causes gridlock	https://twitter.com/GHANANEWSAGENCY/status/1537021884285468674
Feb-23	Fire Outbreak	Tema Community Two, near a mosque close to the Social Security and National Insurance Trust Flats (SSNIT)	Fire sweeps through 15 shops, houses at Tema Community 2	https://www.graphic.com.gh/news/general-news/fire-sweeps-through-15-shops-houses-at-tema-community-2.html
Jul-23	Fire Outbreak	Tema tank yard inside the Kpone Katamanso Municipality of the Greater Accra Region.	Fire destroys three fuel tankers in Tema	https://www.myjoyonline.com/fire-destroys-three-fuel-tankers-in-tema/

Date	Hazardous Event	Location	Impact	Reference
Apr-22	Fire Outbreak	Tema timber market	Fire guts Tema timber market	https://citinewsroom.com/2022/04/fire-guts-tema-timber-market/
Jun-15	Flood	Accra Tema	Over 5,000 Tema residents displaced	https://citifmonline.com/2015/06/accra-floods-over-5000-tema-residents-displaced/
Mar-12	Fire Outbreak	Tema Office of Liberty Capital Ghana Limited (LCGL)	Liberty Capital Ghana Tema Office survives fire outbreak	https://www.peacefmonline.com/pages/local/news/201203/102358.php
Jun-16	Floods (torrential rains)	Tema Site 7	Accra Floods Again, 1 Missing After 6 Hours of Torrential Rain	https://floodlist.com/africa/ghana-accra-floods-june-2016
Jun-17	Flood	Some parts of Greater Accra Region with Tema community 18 severely affected	Floods displace residents in Tema	https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Floods-displace-residents-in-Tema-544963
Aug-14	Fire Outbreak	Tema Community 12	4 die in fire outbreak in Tema	https://newsghana.com.gh/4-die-in-fire-outbreak-in-tema/
Dec-19	Fire Outbreak	Tema Newton	Fire outbreak renders many homeless in Tema Newtown	https://ghheadlines.com/agency/ghana-news-agency/20191224/133328994/fire-outbreak-renders-many-homeless-in-tema-newtown
Apr-19	Fire Outbreak	Tema Community Two	3 siblings perish in fire outbreak	https://www.ghanaiantimes.com.gh/3-siblings-perish-in-fire-outbreak/
Jan-23	Fire Outbreak	Accra Tema	Properties worth over GHs9.8million lost in 2023 Tema fire outbreaks	https://www.modernghana.com/news/1286160/properties-worth-over-ghs98million-lost-in-2023.html
Jan-11	Fire Outbreak	Tema Metropolis	Tema loses GH¢ 3 million worth of properties through fire outbreaks	https://gfmc.online/media/2011/01-2011/news_20110125_gh.html
Jun-09	Fire Outbreak	Accra Tema	Fire outbreak at Unilever Laboratory Tema	https://www.modernghana.com/news/222003/fire-outbreak-at-unilever-laboratory-tema.html
Jan-19	Fire Outbreak	Accra	44 lives lost and GH¢29m worth of properties destroyed in fire incidents in 2018, plus details of regional fire outbreaks	https://bestnewsgh.com/44-lives-lost-and-gh%E2%82%B529m-worth-of-properties-destroyed-in-fire-incidents-in-2018-plus-details-of-regional-fire-outbreaks/
Oct-16	Drought	Accra Tema	Tema stresses care in outdoor burning while drought conditions continue	https://3bmedianews.com/tema-stresses-care-in-outdoor-burning-while-drought-conditions-continue/

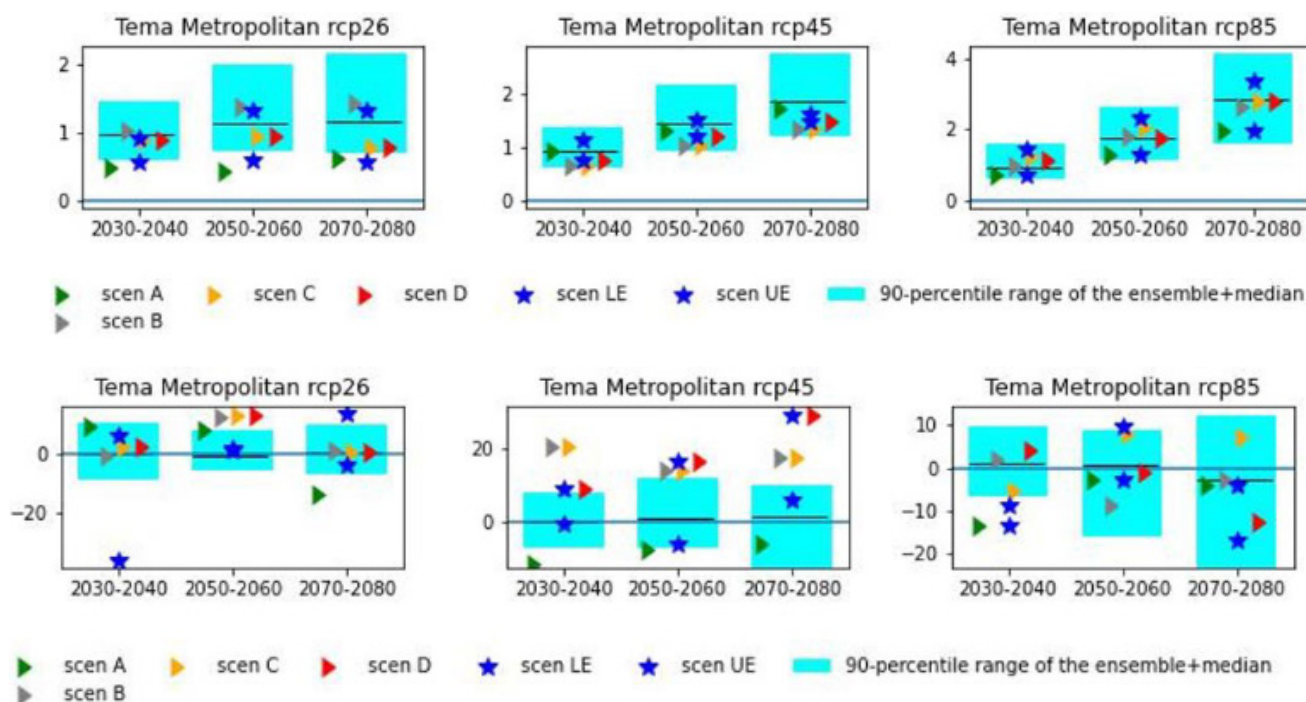
Date	Hazardous Event	Location	Impact	Reference
Sep-08	Fire Outbreak	Tema Harbour	Fire outbreak at Tema fishing harbour	https://allafrica.com/stories/200809040904.html
Jan-21	Fire Outbreak	Tema New-Town	Fire outbreak rages Tema New-Town, Abonkor community	https://www.ghanaweb.com/GhanaHomePage/NewsArchive/Fire-outbreak-rages-Tema-New-Town-Abonkor-community-1150328
Sep-23	Fire Outbreak	Accra Tema	Quantum Oil fire under control	https://www.modernghana.com/news/1262543/quantum-oil-fire-under-control.html
Nov-18	Disease Outbreak	communities in Tema - Awudu and Harbour Electoral areas.	Lifestyles diseases cause of Tema Manhean deaths	https://www.graphic.com.gh/news/general-news/lifestyles-diseases-cause-of-tema-manhean-deaths-ghs.html
Dec-23	Disease Outbreak due to air pollution	Most residents of Tema Industrial Area and its environs have become accustomed to breathing dust, industrial fumes, and stench of industrial waste	Tema Residents Battle for Clean Air in One Of The Most Polluted Cities In Ghana	https://peacefmonline.com/pages/comment/features/202312/496329.php
Nov-18	Disease Outbreak	Tema Newtown	Tema Newtown residents rush for purification rituals over alleged 'mysterious deaths'	https://citinewsroom.com/2018/11/tema-newtown-residents-rush-for-purification-rituals-over-alleged-mysterious-deaths/
Oct-20	Disease Outbreak	Tema Newtown	The 'New Normal' Destroying Livelihoods	https://www.modernghana.com/news/1035918/tema-newtown-beach-the-new-normal-destroying.html

5.3 Future Climate Scenarios

The Tema Metro MMDA is located in the Coastal Climate Zone. This zone is projected to experience an increase in temperature from 1.5°C under RCP 2.6 to 3-4.5°C under RCP 8.5, with RCP 4.5 indicating a midpoint around 2.0°C. Notably, under RCP 8.5 and CMIP 6 projections, there is potential for even higher temperature rises, possibly exceeding an additional 0.5°C. This indicates a significant risk of elevated temperatures in the region, particularly under scenarios with lower greenhouse gas concentrations.

Regarding annual average precipitation, there is an approximately equal likelihood of small increases or decreases compared to current levels, typically ranging around $\pm 10\%$. Extreme scenarios suggest potential changes of up to $\pm 20\%$. The plume plots from CMIP 6 indicate a reasonable alignment between precipitation scenarios, particularly capturing variation well under RCP 2.6. However, for RCP 4.5 and RCP 8.5, there is a notable possibility of substantial increases in rainfall, potentially reaching 20-30% above current levels.

Figure 13: Change in mean annual temperature °C (up) and percentage change in total annual rainfall (down) for Tema Metropolitan Assembly



5.4 Downscaled Climate Change Scenarios

Temperature

(Ankrah et al., 2023) studied extreme temperatures in Coastal Savannah Zone. The study found that generally, the variations in the minimum and maximum temperatures revealed a significant seasonal decadal difference across the zone. The study projected that future maximum temperature will increase significantly in the dry season (November–March) and decrease substantially in the wet (May–July) and minor (September–October) seasons. The maximum projected temperature is expected to increase significantly in the decades of 2050s and 2080s than in the 2030. Nonetheless, there is projected increase in the maximum temperatures in all the noted decades with a predicted highest temperature of 1.6 °C.(Siabi et al. 2023)especially in the Greater Accra region over the last two decades. CC assessment under the new IPCC scenarios and consistent local station data is limited. Consequently, CC assessment is becoming difficult in data-scarce regions in Ghana. This study utilizes six different Regional Climate Models under the 6th IPCC Report’s Shared Socioeconomic Pathway scenarios (SSPs– also corroborated this finding by projecting that climate scenarios suggest that maximum temperatures could rise within the ranges of 0.81–1.45 °C, 0.84–1.54 °C, 0.96–1.70 °C, and 0.98–1.73 °C under SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5, respectively. Similarly, minimum temperatures are expected to increase in the ranges of 1.33–2.02 °C, 1.49–2.22 °C, 1.71–4.75 °C, and 1.75–4.83 °C for the same respective scenarios.

Extreme Heat

Another study by (Siabi, et al. 2023) noted that impervious surfaces form part of the significant factors that cause higher temperatures in urban areas which in turn lead to poor thermal comfort in cities. The study explains that the warming effect of the enhanced urban heat island resulted in a rise in the intensity and frequency of warm temperature extremes in Greater Accra. Additionally, the study found that night time temperatures increased relatively more than recorded day time temperatures in a drop in diurnal temperature range of Greater Accra.

The study further argues that with increasing urbanisation of Tema and Greater Accra Metropolitan Area, warm temperatures are expected to intensify.

Further, the projected significant change in temperatures is expected to increase the frequency and severity of droughts in Greater Accra. It adds that the predicted moisture levels suggest that Accra and Tema will experience heightened aridity in the 2040s under the SSP5 scenario. Consequently, the Greater Accra region is forecasted to be at an increased risk of potential flash droughts, particularly in its southeastern area, by the year 2059.

Precipitation

As well, Padi et al. scrutinized investigated precipitation events in the Greater Accra Metropolitan Assembly, considering both pre-2000 and post-2000 periods. Their investigation disclosed a significant rise in both the magnitude and frequency of extreme precipitation events in the post-2000 period compared to the pre-2000 era. Additionally, a notable shift in the seasonal occurrence of these events was observed, with July being predominant in the pre-2000 period, while this pattern transitioned to June in the post-2000 period.

However, (Siabi, Awafo, Kabo-bah, Derkyi, Akpoti, Anornu, et al., 2023) predicts that precipitation is expected to generally drop by 2059 since total precipitation and the number of times the daily precipitation exceeds 20mm were higher on annual average in Greater Accra. Further, the study asserts that the SSP scenarios are expected show the occurrence of more flood in the future. As the results indicated that consecutive wet days were prolonged of up to 10 days under the SSP3 and SSP5 compared to about 8 days in the historical period. Nonetheless, the number of very heavy rain days was projected to reduce under the SSP scenarios relative to the historical period.

Extreme Rainfall

Siabi notes that, the downscaled climate change scenarios are likely to be harsh due to the intensity of some individual extreme Precipitation events. Additionally, (Ankrah et al., 2023) in a comparison assessment of rainfall events and future projections of regions in the Coastal Savannah Agroecological Zone from 1981 to 2021, realised that, during the wet season, the Greater Accra region experienced the most significant negative (-2.1) and positive (2.1) rainfall anomalies in 1987 (the first decade) and 2009 (the third decade), respectively. The study reports that both the Greater Accra and central regions recorded their highest negative (-2.1) and positive (2.1) minor season rainfall anomalies in 1983 and 1987, respectively, both occurring in the first decade. The study concludes by predicting an increased variations in rainfall in the 2030s, 2050s, and 2080s across all three regions and the entire zone under both models. While the A2 scenarios predict an increase in rainfall for the wet season and a decrease for the minor and dry seasons, respectively, the B2 scenario presents the opposite. The study further extrapolated changes in rainfall patterns under various scenarios (RCP26, RCP4.5, and RCP8.5). The Greater Accra region is projected to experience increases in all months, with the highest change in the dry season. It adds that, across all scenarios, the entire zone displays a clear seasonal pattern with an overall variation in rainfall across the coastal savannah zone ranges between -98.4% and 247.7% under all scenarios.



6

Potential Impacts for Priority Risks Domains

6.1 Initial Assessment of Critical Climate-Related Hazards

The study further conducted an initial assessment of critical climate related hazards in the Tema Metropolitan Assembly using the [ThinkHazard!](#) Tool. The tool was used to assess the severity of climate related hazards in the Metropolis. The results are showed in Table 2 below;

Table 2: Critical Climate related Hazards

Hazard	River Flood	Urban flood	Water Scar- city	Extreme Heat	Wildfire
Level					
Interpretation	Medium	Medium	Medium	Medium	Very Low

In the Tema Metropolis area, urban flood hazard according to the tool was classified as **medium** based on modeled flood information currently available to this tool. This classification indicates that there is a chance of more than 20% that potentially damaging and life-threatening urban floods could occur in the next 10 years. To mitigate this risk, urban planning should prioritize strategies such as improved drainage systems, protection of the Sakumo Ramsar site and flood-resistant urban infrastructure planning and implementation.

Water scarcity was also classified as **medium** according to the tool's current data, suggesting up to a 20% chance of droughts occurring within the same period. It is crucial for water management authorities to enhance water conservation measures and explore alternative water sources to ensure resilience during periods of potential drought.

Additionally, the extreme heat hazard was also categorized as **medium** based on modeled heat information. This classification implies a likelihood of more than 25% that at least one period of prolonged exposure to extreme heat, leading to heat stress, will occur in the next five years.

Conversely, the wildfire hazard is classified as **very low**, with less than a 4% chance of conditions supporting a problematic wildfire causing disruption in any given year in the project area. However, despite this low hazard level based on historical weather data, local factors such as dry fuels and steep slopes may necessitate considering the possibility of wildfires. Collaborative efforts with local fire departments and communities should focus on prevention strategies and preparedness measure

Further, the tool did not provide a classification of the severity of coastal flood, given that the Metropolis is a coastal city, due to the unavailability of appropriate historical data.

6.2 Priority Risk Domains

6.2.1 Water Resources

Climate change poses significant challenges to the water resources of coastal cities, with potential impacts on both wastewater treatment and clean drinking water access. A study by (Adonadaga, 2014) highlights the changing meteorological variables over the past five decades, indicating increasing trends in mean annual temperature and evapotranspiration, coupled with decreasing trends in rainfall for cities like Accra and Tema. The temperature rise by 0.65°C and 1.3°C, along with reduced rainfall by 171.4mm and 83.4mm for Accra and Tema respectively, suggests a drier future. The findings anticipate a potential increase in wastewater reuse due to decreasing water availability, emphasizing the need for efficient water management policies for both municipal and agricultural purposes. The combined effects of climate change on wastewater treatment options and clean drinking water access in coastal cities like Accra and Tema necessitate proactive and adaptable water management strategies to ensure resilience against the challenges posed by a changing climate.

The intersection of climate change induced migration and overpopulation intensifies the challenges in ensuring clean drinking water access in metropolis such as Tema. The influx of climate migrants exacerbates the strain on existing water infrastructure. Increased demand for water resources surpasses the city's capacity to provide clean and sustainable drinking water to its residents (Alhassan, 2014)

Incorporating flood-resilient urban planning measures can help minimize the impact of flooding on water resources. The consistent flooding in Tema, coupled with the pollution of its main drainage systems, Chemu and Sakumo lagoon presents the metropolis with several climate induce risks (Abubakari et al., 2016). The aftermath of flooding can result in persistent water quality issues. Residual contaminants may linger in water sources, affecting the usability of water for agriculture, industry, and domestic purposes long after the floodwaters recede.

6.2.2 Flooding

A study by (Asante & Amuakwa-Mensah, 2014) revealed changes in precipitation for the Coastal Savanna Zone, where Tema is situated. The study notes that by the year 2080, the wet season rainfall is projected to fluctuate between a 52% decrease and a 44% increase. This variability poses a significant challenge for water resource management, potentially impacting water availability for the city. Tema experience flood events almost annually.

The rise in sea levels stands out as one of the primary consequences of climate change in Tema. Projections from the Intergovernmental Panel on Climate Change Fourth Assessment Report indicate an increase from 0.13 meters to 0.60 meters by the late 21st century. The elevated sea levels intensify the vulnerability of coastal areas, predisposing Tema to higher risks of flooding, particularly during storm surges and extreme weather events.

Climate models for the Coastal Savanna Zone, which encompasses Tema, also forecast changes in precipitation patterns. As rainfall is projected to vary from a 52% decrease to a 44% increase by 2080 (Asante & Amuakwa-Mensah, 2014), the metropolis faces the challenge of managing unpredictable water flows. Increased precipitation during the rainy season may contribute to flash floods, threatening both urban infrastructure and community. Extreme weather events, intensified by climate change, may strain existing drainage systems and flood management infrastructure. The potential increase in flooding thus pose a direct threat to the coastal resilience of Tema. Beyond immediate dangers to life and property,

frequent flooding can erode coastal ecosystems, degrade infrastructure, and disrupt economic activities. Coastal communities may face displacement, exacerbating social and economic challenges.

6.2.3 Drought

Among the myriad consequences of climate change, the prospect of an increased frequency of droughts poses an alarming challenge. Extreme maximum temperatures amplify the demand for water by vegetation and accelerate soil moisture evaporation, disrupting the balance of hydrological cycles, influencing the timing and volume of water availability contribute to prolonged periods of water scarcity, making ecosystems and human communities more vulnerable. This results in a risk of food insecurity, affecting crop yields and livestock. Droughts also have cascading health impacts, affecting sanitation and hygiene. Reduced water availability can compromise access to clean water, leading to waterborne diseases and sanitation-related health issues.

6.2.4 Wildfires

As the metropolitan in Tema increases in urbanisation, the city faces a challenge of fire outbreaks, exacerbated by the impacts of climate change. The aforementioned climate change scenarios could contribute to the intensification and increased frequency of heatwaves. Elevated temperatures could thus create a conducive environment for spontaneous combustion. Especially in areas with flammable materials. Tema's industrial zones and large informal settlements may experience as a result a potential surge in fire incidents during prolonged periods of extreme heat. As well, the occurrence of fire outbreaks during the dry season from electrical faults in households is more susceptible. Faulty electrical wiring, blowing up of electric transformers and illegal connections pose a significant risk of fire outbreaks in Tema, especially during the dry season as well as high wet days. As the demand for electricity increases, the strain on electrical systems grows, leading to the potential for short circuits and electrical fires.

Changes in agricultural practices, industrial processes, and energy consumption patterns could factor in to contribute to an elevated risk of fire outbreaks. The combination of elevated temperatures conditions enhances the likelihood of vegetation drying out, creating favourable conditions for bushfires. Dry vegetation becomes highly susceptible to ignition, posing a heightened risk of fire outbreaks in both urban and peri-urban areas

Enhancing community awareness regarding the increased risk of fire outbreaks due to climate change is paramount. Implementing public education campaigns and organizing drills can empower residents to respond effectively and minimize potential damage. As well, strengthening regulations related to fire safety, land use, and industrial processes is crucial. Strict enforcement of these regulations can help prevent human-induced fires and ensure that activities prone to fire risks adhere to safety standards.

6.2.5 Agriculture

Climate change brings about shifts in temperature and precipitation patterns, leading to altered growing conditions for crops. For rain dependent farmers in Tema, the unpredictability of weather events makes it challenging to adhere to traditional planting calendars. Variability in rainfall and temperature extremes can compromise crop yields and disrupt established agricultural practices. Even for irrigated farms, the threat of depleted water resources challenges the sustainability of irrigation systems. Regions already grappling with water scarcity are particularly vulnerable to reduced agricultural productivity. The projected increase in the number of extreme climate events pose immediate threats to crops, livestock, and agricultural infrastructure. Climate-related events such as droughts and floods can disrupt food

production, contributing to food shortages and malnutrition. Vulnerable populations, particularly in low-income regions, are at an increased risk of nutritional deficiencies. Moreover, hotter temperatures create favourable environments for the spread of pests and diseases. Insect pests, plant pathogens, and invasive species may expand their range, posing new challenges to crop protection

Also, extreme weather events such as flood could contribute to soil degradation and erosion. These events can also result in physical damage to agricultural infrastructure, disrupt agricultural activities, and cause economic setbacks for both sectors.

For many in Tema, small-scale sea fishing is not just a livelihood but a way of life. Storm surges and unpredictable weather patterns could pose direct threats to the safety of small-scale fishing activities. Additionally, the potential disruptions caused by climate change can lead to reduced catch sizes, economic losses, and increased financial strain on fishing communities. Changes in sea temperature and environmental conditions may alter the spawning and breeding patterns of fish species. As well, small-scale fishermen, reliant on specific seasons for bountiful catches, may face disruptions in their traditional fishing calendar, affecting their catch and income.

6.2.6 Health

The predicted scenarios of rising global and local temperatures exposes populations to increased risks of heat-related illnesses, such as heatstroke and dehydration. Vulnerable groups, including the elderly and those with pre-existing health conditions, face heightened susceptibility. The rise in extreme heat events is also associated with an uptick in heat-related mortality, particularly in urban areas.

Climate patterns such as the number of wet days and dry days influence the distribution and behaviour of disease vectors, such as mosquitoes and ticks, leading to the changing geographic prevalence of infectious diseases. Regions previously unaffected may witness the spread of diseases like malaria, dengue fever, and Lyme disease (Fadda, 2020). Additionally, warming temperatures can shorten incubation periods for certain pathogens, potentially intensifying disease transmission rates (Harvell et al., 2002).

Further, these climate changes create conditions conducive to the spread of waterborne diseases, including diarrhoea. Floods and storms can lead to the contamination of water sources, posing immediate health risks and contributing to the long-term burden of waterborne diseases. Also, extreme climate change-induced events, such as flooding causing loss of homes, and displacement can contribute to heightened mental health challenges. The stressors associated with climate-related disasters, coupled with the anticipation of future impacts, may exacerbate anxiety, depression, and post-traumatic stress disorders within affected communities

Although the industrial nature of Tema makes it susceptible to low air quality, climate change can further contribute to exacerbate air quality through factors like increased wildfire frequency, high humidity levels or prolonged harmattan (dry weather) season. Poor air quality aggravates respiratory conditions such as asthma and chronic obstructive pulmonary disease.



7

Climate Change Risk Assessment for TMA

7.1 Stakeholder Engagement

Tema Metropolitan Assembly workshop focused on co-developing a district-specific risk and vulnerability assessment and generating priority adaptation plans. The workshop aimed to assess the district's specific risks and vulnerabilities, create unique adaptation strategies, and promote cooperative action toward creating a more resilient future for Tema's communities by bringing together relevant stakeholders. 32 key stakeholders from the municipality's relevant sectors attended the workshop, including municipal officers, representatives from government agencies that deal with the effects of climate change, traditional authorities, community groups, representatives of people with disabilities, non-governmental organizations, corporate social organizations, and the media.

The participatory workshop commenced with an introduction that set the context and presented the rationale of Ghana's National Adaptation Plan process and the necessity for conducting a vulnerability risk assessment of the Tema Metropolitan Assembly (TMA), emphasizing key climatic hazards and vulnerable areas.

Following this, participants had broken out into small groups to identify specific climatic hazards within the municipality, map areas and resources at risk, and discuss current adaptation strategies employed by the community.

Upon reconvening as a plenary, the prioritization of hazards had been collectively determined based on severity and impact. Seasonality calendars of hazards and livelihoods had been collaboratively developed, highlighting vulnerable periods. Participants had engaged in identifying prioritized adaptation actions for affected sectors, focusing on practical and locally relevant measures. Challenges in implementing adaptation actions had been discussed, with brainstorming sessions to propose solutions.

Figure 14: Group picture from Stakeholder Workshop



Identification of Critical Climate Change Vulnerabilities

7.2 Hazard Identification and resource mapping

The participatory group discussions effectively aided in experts and members of the metropolis co-identifying based on the expertise and experience with climate hazards in the metropolis. The groups conducted an assessment of climate hazards in Tema Metropolis, identifying and mapping extreme weather events such as floods and coastal erosion, air pollution, wildfires, windstorms, and wetlands encroachment.

7.2.1 Main Climate Hazards and Impacts

Both groups identified the main climate hazards affecting Tema Metropolis. The co-generated climate hazards prominent in the metropolis include

- Floods,
- Coastal erosion
- Air pollution
- Wildfires
- Windstorms
- Wetlands encroachment.

They emphasized the significant impacts of these hazards on livelihoods, health, and well-being in the community. Industrial activities, exacerbated by climatic conditions like long dry spells during harmattan, contribute significantly to air pollution. The encroachment of wetlands further compounds biodiversity loss and increases flood risks, highlighting complex interplays between climate hazards and urban development.

7.2.2 Current Adaptation Strategies

According to stakeholder discussions, residents in Tema Metropolis have developed various adaptation strategies over time. These strategies include temporal relocation during floods, the use of indigenous technologies to fortify housing, and reliance on relief efforts from NADMO. Additionally, community members often turn to makeshift measures such as building barriers to protect their homes from floodwaters. These strategies underscore the community's resilience in facing recurrent climate challenges.

Additionally, several strategies are being implemented by the Tema Metropolitan Assembly to manage and adapt to climate risks. These strategies encompass construction of sea defense walls to mitigate coastal erosion, clearing of blocked gutters and sewage systems to reduce flood risks, and initiatives to improve air quality through air quality assessment of industrial and vehicular activities and enforcement of spatial planning bye-laws. Furthermore, sensitization campaigns by fire services and NADMO aid in wildfire prevention and enhance community preparedness. Efforts to address wetlands encroachment include strict permit issuance and promotion of tree planting, alongside enforcing regulations to mitigate windstorm impacts.

[illegible]

7.2.3 Effectiveness and Challenges of Adaptation Strategies

7.2.4 Climate Hazard Trends

Further, the groups conducted a trend analysis of climatic hazards in Tema Metropolis, revealing dynamic shifts over recent decades. They noted a decrease in coastal erosion attributed to tidal waves over the past decade, contrasting with an increase in flooding events. Persistent industrial activities and urban expansion have contributed to a consistent rise in air pollution, while occurrences of wildfires have decreased. However, encroachment on wetlands has continued to increase, posing new challenges. Wind storms, though initially decreasing, have shown recent upward trends, necessitating adaptive responses from local authorities and communities.

Table 3: Trends and Prioritisation of Hazards

Name of hazards or risks	Time line in years (past time 10-20 years ago (increasing or decreasing)	10 years ago (Increasing or decreasing)
Coastal Erosion (Tidal Waves)	Increasing	Decreasing
Flooding	Decreasing	Increasing
Air (industrial, Vehicle) Pollution*	Increasing	Increasing
Wildfires	Increasing	Decreasing
Wetlands Encroachment	Decreasing	Increasing
Wind Storm	Decreasing	Increasing

**Due to factories at Tema and heavy vehicle movement in and out*

7.3 Seasonality of Climate Risks

The results from stakeholder discussions revealed a comprehensive assessment of climate hazards within the Tema Metropolitan Assembly (TMA). The group discussions assigned scores to gauge the intensity and seasonality of co-identified climate hazards, providing a nuanced understanding of their impact and vulnerability in different months, as summarized in Error! Reference source not found..

- **Coastal erosion** emerged as a persistent threat throughout the year, consistently demonstrating high impact and vulnerability. However, slight decreases in vulnerability were noted during May, June, September, and October, suggesting some seasonal variability in its severity. This hazard poses significant risks to coastal infrastructure and communities, necessitating adaptive measures to mitigate its effects, particularly during peak vulnerability periods.
- **Flood vulnerability** exhibited notable variability, with pronounced peaks observed during February, June, July, August, and September. Conversely, vulnerability generally decreased in May, October, November, and December, reflecting the influence of seasonal rainfall patterns and flood control measures. The identification of these high-risk periods underscores the importance of targeted interventions to enhance flood resilience and protect vulnerable populations.
- **Air pollution** was identified as a pervasive concern throughout the year in TMA, with consistently high impact and vulnerability across all months. Stakeholders attributed this to industrial activities, vehicular emissions, and rapid urbanization processes, emphasizing the urgent need for continuous monitoring and effective mitigation strategies. Addressing air quality issues is crucial for safeguarding public health and improving the overall environmental sustainability of the region.
- **Wetlands encroachment** demonstrated fluctuating vulnerability across the months, with heightened impact observed during January to April and November to December. Moderate vulnerability was noted in May, June, and October, while the least vulnerability occurred in July, August, and September. This complex environmental challenge, particularly evident at the Sakumo Ramsar site, threatens biodiversity, ecosystem services, and exacerbates flood risks. Effective management strategies are essential to preserve wetland ecosystems and mitigate their adverse impacts on local communities.
- **Windstorm vulnerability** also exhibited seasonal variation, with high vulnerability recorded from January to April and July to November. The months of May, June, and December showed slightly lower vulnerability, reflecting seasonal wind patterns and their potential impacts on infrastructure and

community resilience. Similarly, wildfires were identified as a significant hazard with high vulnerability during specific months, underscoring the need for proactive fire management strategies and community preparedness initiatives.

Table 4: Seasonality calendars of Hazards

Hazard	Months of the Year											
	J	F	M	A	M	J	J	A	S	O	N	D
Coastal Erosion	3	3	3	3	3	3	3	3	3	3	3	3
			2	3	3	3	2	2	3	3	1	1
Flood			1		3	3	2		3	3		
					3	3		3	3	3		
					1	1	1					
Air pollution	3	3	3	3	3	3	3	3	3	3	3	3
	3	3	3	3	3	3	3	3	3	3	3	3
	1	1	1	1	1	1	1	1	1	1	1	1
Wetlands en- croachment	3	3	3	2				2	3	3	3	3
	1	1	1	1	1	1	1	1	1	1	1	1
	2	2	2	3	3	3	3		3	3	2	2
Windstorm	3	3	3					3	2	2	3	3
	1	1	1	1	1						1	1
Wildfires	3	3	2					2			3	3
	1											1
	2	2							2	2		

Scores: 3 = Highly impacted and vulnerable; 2 = Medium impacted; 1 = Moderately impacted and 0 = No impact

7.4 Perceived Impact of Climate Hazard on Livelihood

Further, the results from stakeholder discussions highlighted key vulnerabilities and risks across various sectors in the Tema Metropolitan Assembly (TMA), particularly in the Agriculture, Biodiversity, Fisheries, Gender and Trade sectors

- **Agriculture, Biodiversity, and Fisheries:** One group identified flooding, wetland loss, and pollution as major risks affecting agriculture and biodiversity.
- The fisheries sector faces vulnerabilities such as tidal waves, coastal erosion, pollution, and windstorms at sea, impacting marine resources and coastal livelihoods.
- **Gender and Trade:** Another group emphasized gender inequalities exacerbated by climatic hazards, particularly affecting women engaged in trade activities like fish farming. They noted health risks from smoke inhalation during fish smoking, highlighting vulnerabilities among women and elderly populations due to weakened physical capacities.

Both groups highlighted multifaceted factors exacerbating these vulnerabilities, including deforestation, wetland encroachment, overfishing, and extreme weather events. Vulnerable groups identified include residents along the Sakumono basin, fishermen, coastal residents, porters, fishmongers, fish processors, the aged, persons with disabilities, women, children, and migrants.

Figure 16: Group presentation of findings of impacts of climate risks on productive sectors of TMA



Efforts to manage these risks include:

- **Agriculture:** Tree planting, well-constructed drains, and climate-smart agricultural practices.
- **Fisheries:** Early warning systems and education on tidal waves.
- **Gender:** Gender mainstreaming policies, access to education and skills training, and legal frameworks protecting women's rights.
- **Trade:** Diversifying markets, improving trade infrastructure, and supporting SMEs through capacity-building and financial assistance.

7.5 Roles of Stakeholders and Challenges in implementing adaptation actions for the Tema Metropolitan Assembly

Stakeholders play a crucial role in addressing challenges in implementing adaptation actions for the Tema Metropolitan Assembly. To ensure sustainable development and resilience in the face of climate change impacts.

Roles of Stakeholders: Stakeholders identified through an individual quick survey, institutions involved in climate adaptation efforts within the Tema Metropolitan Area (TMA). The identified relevant institutions the Environmental Protection Agency (EPA), agriculture and fisheries departments, Ghana Meteorological Agency (GMET), forestry services, waste management authorities, National Disaster Management Organization (NADMO), Fire Service, Police Service, as well as various community-based organizations (CBOs). Their roles encompass monitoring climate risks, implementing adaptation strategies, conducting outreach and education, and coordinating resilience-building efforts across different sectors.

Challenges in Implementing Climate Adaptation Actions: However, implementing adaptation actions faces several challenges. Challenges in implementing adaptation actions include;

- **Inadequate Monitoring of Green Belt and Land Reservation Areas:** Lack of effective monitoring systems hinders proper management and conservation of critical green spaces and land reserved for environmental protection.
- **Entrenched Gender Norms:** Deep-seated societal norms limit the effectiveness of gender mainstreaming efforts in adaptation planning. Particularly in addressing gender-specific vulnerabilities and promoting inclusive strategies. These norms often perpetuate unequal power relations between men and women, leading to disparities in access to resources, decision-making processes, and opportunities for development.
- **Resource Constraints:** Limited financial resources impede organizations' ability to implement adaptation plans and acquire necessary infrastructure and equipment to effectively respond to climate hazards.
- **Limited Institutional Capacity:** Many organizations face challenges in building and maintaining the institutional capacity needed for robust climate adaptation planning, implementation, and monitoring.
- **Political Resistance to Bye-law Enforcement:** Resistance from political entities poses challenges to enforcing regulations aimed at mitigating climate impacts, such as pollution controls and land use regulations.

7.6 Gender-specific vulnerability assessment

In the Tema Metropolitan Assembly, the levels of vulnerability among gender and social groups reveal distinct disparities in exposure, sensitivity, and adaptive capacity to climate risks. Women remain highly vulnerable due to limited access to economic resources, education, and essential services, compounded by societal roles that heighten their dependency on climate-sensitive activities. Men, while exhibiting lower vulnerability, still face challenges related to the impact of climate change on their livelihoods, particularly in agriculture and trade, which underscores the need for targeted interventions to enhance resilience across all sectors.

Youth experience moderate vulnerability, as their exposure to climate hazards, such as flooding and extreme heat, is tempered by slightly higher adaptive capacity compared to women. However, barriers to education, economic resources, and infrastructure limit their ability to fully mitigate the impacts of climate change, affecting their long-term development and prospects. Persons with disabilities (PwD) represent the most vulnerable group, with very high sensitivity and low adaptive capacity due to systemic barriers that impede their access to resources and coping mechanisms. They are disproportionately affected by climate-induced challenges, which exacerbates existing inequalities and requires urgent, inclusive policy measures.

The varying levels of vulnerability among these groups highlight the importance of implementing inclusive and equity-driven adaptation strategies in the Tema Metropolitan Assembly.

Table 5: Assessment of current gender-specific climate change risks

Group	Hazard Description	Exposure	Sensitivity	Adaptive Capacity	Overall Vulnerability	Comments/Impacts
Women, children & elderly	Erratic rainfall, increased temperatures Residents deprived along three dimensions –monetary poverty, education, and basic infrastructure services	High	High	Low	High	Women, children, and the elderly in Tema face high exposure and sensitivity to urban-specific climate risks such as flooding, heatwaves, and air pollution. These groups are often deprived of sufficient monetary income, access to quality education, and equitable infrastructure services, which reduces their adaptive capacity. Their overall vulnerability is high, as their socioeconomic dependence and limited access to safety nets make them more likely to bear the impacts of climate-related hazards. The urban setting intensifies their challenges, with poor drainage systems and densely populated areas amplifying their risk during extreme weather events.
Youth	Erratic rainfall, increased temperatures Residents deprived along three dimensions –monetary poverty, education, and basic infrastructure services	High	Medium	Medium	Medium	The youth in Tema experience high exposure to urban climate hazards but have moderate sensitivity and adaptive capacity. Limited access to financial resources and adequate infrastructure increases their vulnerability. However, their potential for skill development and access to emerging urban opportunities, such as manufacturing and service industries, provides pathways to reduce long-term climate risks. Their overall vulnerability is moderate, with climate change threatening their aspirations for stable employment and economic progress.

Group	Hazard Description	Exposure	Sensitivity	Adaptive Capacity	Overall Vulnerability	Comments/Impacts
People with disability	Erratic rainfall, increased temperatures Residents deprived along three dimensions –monetary poverty, education, and basic infrastructure services	High	Very high	Very Low	Very high	People with disabilities in TMA are the most vulnerable demographic group, with very high sensitivity to urban climate risks and very low adaptive capacity. High levels of deprivation in economic resources, accessibility to inclusive infrastructure, and tailored social services compound their vulnerability. Flooding, in particular, severely impacts their mobility and safety, while heatwaves exacerbate existing health challenges. This group faces significant barriers to adaptation, leaving them disproportionately affected by urban climate hazards.
Men	Erratic rainfall, increased temperatures Residents deprived along three dimensions –monetary poverty, education, and basic infrastructure services	High	Medium	High	Low	Men in Tema face high exposure to urban climate risks but generally have lower overall vulnerability due to moderate sensitivity and relatively higher adaptive capacity. Access to better employment opportunities, particularly in industries and services, improves their resilience. However, the impacts of extreme weather events, such as flooding disrupting informal trading and temperature extremes affecting physical labor, still pose significant challenges. While their vulnerability is lower compared to other groups, socioeconomic inequalities and infrastructure gaps remain critical factors in determining their ability to adapt effectively.

7.6.1 Roles of Stakeholders and Challenges in implementing adaptation actions for the Tema Metropolitan Assembly

Stakeholders play a crucial role in addressing challenges in implementing adaptation actions for the Tema Metropolitan Assembly. To ensure sustainable development and resilience in the face of climate change impacts.

Roles of Stakeholders: Stakeholders identified through an individual quick survey, institutions involved in climate adaptation efforts within the Tema Metropolitan Assembly. The analysis revealed that the

identified roles of stakeholders encompass environmental protection, promoting youth and women in agricultural development, disease prevention, local government interventions, and disaster prevention. Stakeholders from institutions such as the Department of Agriculture, Forestry Department, Fisheries, NADMO, NGOs focused on agriculture and climate activities, the Environmental Protection Agency, traditional authorities, assembly members, and the media contribute through supervision, coordination, and direct operational involvement. They collectively aim to educate communities about climate risks, promote food security, advance sustainable agriculture, engage in disaster prevention, sensitize the public, and collaborate extensively with other stakeholders to build resilience and mitigate climate impacts.

Challenges in Implementing Climate Adaptation Actions: However, implementing adaptation actions faces severe challenges. Challenges constraining implementing adaptation actions include;

- **Bush fires and animal destruction of tree seedlings:** Frequent bush fires and animals grazing on young tree seedlings pose significant threats to reforestation efforts and tree cover preservation, hindering initiatives aimed at mitigating climate risks.
- **Water availability for seedlings during dry seasons:** Inadequate water supply for seedlings during dry seasons limits successful planting and survival rates, impacting agriculture and afforestation programs that depend on consistent water access.
- **Inadequacies in tractor services and combine harvesters:** Limited availability and access to agricultural machinery like tractors and combine harvesters delay planting and harvesting schedules, affecting agricultural productivity and food security efforts.
- **Resource constraints and logistical limitations:** Insufficient financial resources, coupled with logistical challenges in transporting equipment and supplies to remote areas, hamper the effective implementation of adaptation measures and community resilience-building efforts.
- **Capacity gaps in climate change knowledge and adaptation planning:** Limited knowledge and skills among stakeholders regarding climate change dynamics, adaptation strategies, and effective planning impede the development and implementation of robust climate resilience programs.
- **Occasional lack of cooperation from communities:** Resistance or reluctance from local communities to participate in adaptation initiatives due to varying perceptions, cultural factors, or communication gaps undermines collaborative efforts and community engagement strategies.
- **Erratic rainfall patterns and floods disrupting activities:** Unpredictable rainfall patterns and increased frequency of floods disrupt agricultural activities, infrastructure development, and other adaptation projects, leading to setbacks and increased vulnerability.
- **Need for comprehensive strategies to overcome barriers:** The complex nature of climate change impacts requires holistic strategies that address interconnected challenges such as environmental degradation, socio-economic vulnerabilities, and institutional capacities.
- **Mode of community entry and communication skills affecting engagement:** Challenges in effectively communicating adaptation strategies and building trust with communities due to inadequate communication skills or inappropriate community entry methods hinder the adoption and success of adaptation initiatives.

- **Logistics, physical tools, and transportation challenges for on-the-ground implementation:**
Difficulties in procuring and maintaining necessary physical tools, equipment, and transportation infrastructure for implementing adaptation measures in remote and rural areas constrain operational effectiveness and timely project delivery.



8



Conclusions & Recommendations

8.1 Conclusions

The Tema Metropolitan Assembly (TMA) faces significant climate change impacts according to various projections and studies. Under RCP 2.6 to RCP 8.5 scenarios, temperatures are expected to rise by 1.5°C to 4.5°C by the end of the century, with potential additional increases under higher greenhouse gas concentrations. Precipitation trends indicate a likelihood of minor fluctuations around current levels, with extremes possibly increasing by up to $\pm 20\%$. Particularly under RCP 4.5 and RCP 8.5, there is a substantial possibility of intensified rainfall by 20-30% above current levels. Studies emphasize that urbanization exacerbates temperature rises through the urban heat island effect, increasing the frequency and intensity of heat extremes and altering precipitation patterns. These changes are projected to heighten the risk of droughts and floods in the region, underscoring the need for adaptive strategies and robust climate resilience measures in the Tema metropolitan area.

The climate risk assessment for the Tema Metropolitan Assembly was conducted through a collaborative and participatory process, engaging local stakeholders including community leaders, environmental experts, and representatives of vulnerable groups. This inclusive approach ensured a comprehensive understanding of the specific climate risks facing TMA.

The TMA's climate risk assessment has identified several first and second-order priority risk domains based on the locale's specific vulnerabilities:

- Coastal Erosion (Tidal Waves)
- Flooding
- Air (Industrial, Vehicle) Pollution
- Wildfires
- Wetlands Encroachment
- Wind Storm

Key findings from the assessment across various sectors highlight significant vulnerabilities and the urgent need for targeted adaptation strategies:

Agriculture: Climate change poses serious risks to agriculture in Tema, particularly through increased flooding that contaminates water sources and destroys crops, jeopardizing food security and exacerbating poverty. Unpredictable weather patterns disrupt traditional planting calendars, while higher temperatures escalate water demands and accelerate soil moisture evaporation. Pests and diseases thrive in these warmer conditions, further threatening agricultural productivity. Soil degradation and erosion caused by floods compound these challenges, impacting farmlands and agricultural sustainability.

Cities and Urban Land Use: Industrial activities in Tema contribute prominently to air pollution, affecting public health and air quality. Coastal erosion emerges as a major concern, jeopardizing infrastructure and homes along the coastline, potentially leading to displacement and economic losses. Urban expansion exacerbates these risks by encroaching on agricultural lands, displacing farmers, and contributing to informal settlements lacking essential services like clean water. Damage to infrastructure from heavy rains, particularly along vital corridors such as the Tema motorway, further compromises urban safety and resilience.

Disaster Risk Reduction: Heavy rainfall frequently triggers flooding in lagoons and Ramsar sites, exacerbated by urban encroachments and inadequate drainage systems. The expansion of informal settlements and slum areas increases vulnerability to fire outbreaks during dry seasons, threatening lives and livelihoods. Coastal areas face heightened vulnerability due to rising sea levels during storm surges and extreme weather events, often resulting in severe damage to housing infrastructure and community displacement.

Health: Air pollution, exacerbated during long humid and dry periods like harmattan, significantly impacts resident health in Tema. Increased respiratory diseases and skin disorders are prevalent among residents, exacerbated by exposure to pollutants from industrial emissions and vehicular exhaust. Climate-related disasters heighten community stress levels, potentially leading to increased incidences of anxiety, depression, and post-traumatic stress disorders among affected populations.

Biodiversity: Climate change poses critical risks to biodiversity in Tema, threatening habitats through deforestation, habitat loss, and encroachment on wetlands. These environmental disruptions destabilize ecosystems, endangering diverse plant and animal species essential for ecological balance and human well-being. Fragmentation of landscapes due to urban development and agricultural expansion restricts species' ability to migrate or adapt to changing climatic conditions, exacerbating their vulnerability to extinction and increasing flood risks in the region.

Gender: Gender inequalities exacerbate vulnerabilities during climate-related events in Tema, with women and vulnerable groups disproportionately affected. Increased caregiving responsibilities and reduced access to resources heighten their exposure to health risks and economic hardships. Gendered roles in sectors like fish farming expose women to smoke inhalation during traditional fish smoking practices, contributing to respiratory problems and other health complications among affected communities.

Water Resources and Systems: Climate risks severely challenge water resources and systems in Tema, particularly through the dual threats of flooding and prolonged droughts. Floods overwhelm infrastructure designed to manage storm water and sewage, contaminating water bodies with pollutants and compromising water quality for communities reliant on these sources. Conversely, droughts diminish water availability, exacerbating competition among users and stressing already strained water supplies and agricultural production. Rising temperatures further exacerbate these challenges by altering precipitation patterns, impacting the quantity and timing of rainfall critical for water availability and quality.

Addressing these co-identified climate risks requires integrated and adaptive strategies tailored to enhance resilience and sustainability across all sectors in the Tema Metropolitan Assembly. By prioritizing the proposed adaptation measures and fostering collaboration among stakeholders, Tema can mitigate current vulnerabilities and build resilience against future climate impacts, ensuring the well-being and security of its communities in the face of a changing climate landscape.

8.2 Recommendations for TMA

The government of Ghana has acknowledged the profound impact of climate change and has taken proactive steps to address its effects across various sectors. National frameworks like the National Climate Change Policy (NCCP) and the National Climate Change Adaptation Strategy (NCCAS) prioritize adaptation strategies to mitigate the risks associated with climate change. The NCCP specifically emphasizes the need for gender-responsive measures to ensure that vulnerable groups, particularly women, are supported in adapting to changing climatic conditions. Furthermore, the National Disaster Management Organization (NADMO) plays a crucial role in disaster preparedness and response, coordinating efforts across the country to minimize the effects of climate-related hazards.

For Tema, it is essential to adopt similar national frameworks at the local level, considering the unique challenges and vulnerabilities of the district. To enhance resilience and effectively tackle the impacts of climate change, the study recommends to Tema Metropolitan Assembly the following key actions. By implementing these recommendations, Tema can build a resilient, climate-adaptive community, ensuring a sustainable future for its citizens while addressing both current and future climate-related challenges.

1. **Localized Action Plans:** Develop city-specific climate change adaptation plans that reflect the district's unique vulnerabilities and needs. These plans should align with national frameworks but focus on the particular context of Tema.
2. **Gender-Specific Programs:** Design programs that empower women in agriculture by providing access to drought-resistant crops, training, and financial resources. Partner with women's groups for community outreach and education to ensure these initiatives reach the intended beneficiaries.
3. **Capacity Building:** Invest in strengthening local institutions and communities to implement climate adaptation measures effectively. Building capacity will ensure that the district can respond to the challenges posed by climate change.
4. **Research and Data Collection:** Invest in localized climate research and monitoring to gather data specific to Tema. This will help in identifying climate trends, risks, and vulnerabilities in the district, allowing for targeted interventions.
5. **Ecosystem-Based Approaches:** Promote the adoption of green infrastructure, sustainable land use practices, and ecosystem-based adaptation to enhance the district's natural resilience and reduce the impact of climate risks.
6. **Funding for Adaptation Efforts:** Explore innovative financing mechanisms, such as public-private partnerships and climate finance initiatives, to support climate adaptation efforts in Tema.

8.3 Supporting Policies to Streamline Adaptation Options

The consultations also recommended policies, plans and guides through which the recommended adaptation options and impacts could be streamlined to mitigate the vulnerabilities of the identified risks. This included;

- The National Climate Change Policy sets out overarching strategies to mitigate and adapt to climate change impacts nationwide.
- The Ghana National Spatial Development Framework (NSDF) guides spatial planning efforts, ensuring sustainable urban and regional development that considers climate resilience.

- The Medium Term Development Plan outlines specific developmental goals and strategies, including infrastructure resilience and disaster risk reduction measures.
- The Tema Metropolitan Assembly Annual Action Plan operationalizes local initiatives, such as enhancing flood-resilient urban planning and improving community preparedness.
- Additionally, the Local Government Act, 2016 (Act 936), empowers local governments to implement climate adaptation measures effectively. These policies collectively support the integration of climate adaptation options across sectors, promoting sustainable development and resilience in Tema.

ADAPTATION ACTION PLAN FOR THE TEMA METROPOLITAN ASSEMBLY



9



Adaptation Action Plan for the Tema Metropolitan Assembly

9.1 Introduction

The development of the Tema Adaptation Plan (TAP) is a landmark in this journey, reflecting the Assembly's proactive stance. Through a detailed vulnerability assessment conducted in phases, the TAP identifies key sectors and areas of concern. These findings are translated into actionable strategies to safeguard livelihoods, infrastructure, and the environment. At its core, the TAP is a call to action for Tema and a model for other metropolitan, municipal, and district assemblies across Ghana. By fostering collaboration, leveraging evidence, and aligning with the broader goals of Ghana's NAP framework, Tema is not only enhancing its climate resilience but also contributing to the collective effort needed to combat one of the most pressing challenges of our time. This plan serves as a testament to the power of local action in the global fight against climate change.

A foremost part of a successful adaptation planning is understanding the present and future climate risks and vulnerabilities, which can inform the development of appropriate adaptation strategies. This insight provides deeper understanding of the distribution of vulnerabilities across various sectors. In Phase I of the vulnerability assessment, the focus was on assessing the socio-economic conditions and identifying the current impacts of climate change in Tema. Phase II involved a qualitative analysis of vulnerabilities across specific areas and key climate-sensitive sectors. In Phase III, a quantitative evaluation of data was conducted, along with climate projections tailored to the metropolis, offering a thorough understanding of both present and future climate scenarios. The Climate Change Vulnerability Assessment (VA) for Tema Metropolitan Assembly provides essential insights into the extent of climate-induced vulnerabilities affecting the area.

As part of Ghana's NAP process, the development of this adaptation plan marks the next step in Tema Metropolitan Assembly's adaptation planning efforts. The preparation of this plan was a pilot initiative designed to implement the findings from the Metropolitan's Vulnerability Assessment (VA), with the aim of positioning the Metropolitan on a path toward building climate resilience while also promoting economic and social development. The Tema process is unique at the subnational level in Ghana and offers valuable lessons and guidance for adaptation planning in other local governments.

The creation of the Tema Adaptation Plan (TAP) involved the collaboration of diverse stakeholders who worked to transform the vulnerability assessment results into a practical plan designed to enhance resilience and adaptive capacity in key sectors across the Metropolitan. The adaptation plan is targeted at the Tema Metropolitan Assembly and the Environmental Protection Agency (EPA), who will oversee its implementation. Additionally, the plan will provide guidance to various stakeholders in the Metropolitan who will play a role in its execution. Furthermore, the plan serves as a model for developing adaptation strategies in other metropolitan, Metropolitan, and district assemblies (MMDAs).

Box 1. Climate Change Vulnerability Assessment for the Tema Metropolitan Assembly

Ghana's EPA, with support from the Tema Metropolitan Assembly (TMA), conducted a climate change vulnerability assessment for the Metropolitan in 2023–2024. This comprehensive assessment included an analysis of historical and projected climate patterns, participatory risk mapping to pinpoint vulnerable locations, and an evaluation of community resilience using a matrix-of-functions approach. Additionally, vulnerability scores were derived for six key sectors: agriculture; biodiversity and ecosystems (forests); water resources; health and sanitation; disaster risk reduction and transportation; and mainstreaming gender. The participatory approach to this scoring ensured that all relevant stakeholders were in concord of the most vulnerable sectors of Tema 's economy.

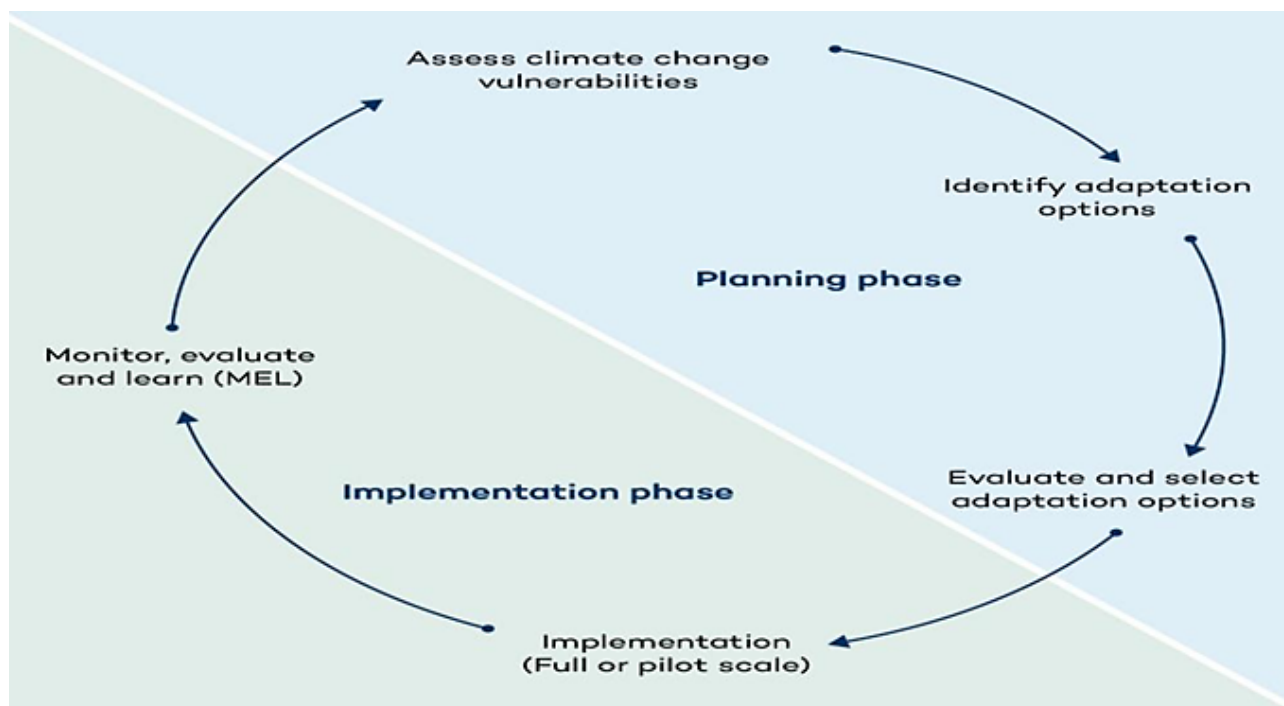
The vulnerability assessment reviewed both current climate change impacts and anticipated future scenarios, identifying pathways to inform adaptation strategies. Priority areas for action were established as a foundational step for TMA's adaptive approach: "Building climate resilience to support sustained economic and social development, despite climate changes anticipated by 2050."

Source: EPA, 2023

Considering the limited resources and various development demands, the TMA must strategically determine which climate adaptation actions to prioritize. These actions aim to reduce the negative impacts of climate change and, when possible, take advantage of any opportunities that changing conditions may present. Adaptation strategies may involve a wide range of efforts, such as enhancing community knowledge, establishing supportive institutions, and implementing systems like land-use planning or insurance mechanisms.

The selection of appropriate adaptation measures is based on an understanding of current and anticipated vulnerabilities, which is informed by a vulnerability assessment. This assessment incorporates historical climate data, future climate projections, and socio-economic factors to provide a comprehensive view. This section details the process for identifying, assessing, and prioritizing adaptation options, along with the resources needed for successful implementation and potential strategies for resource mobilization. The TMA's adaptation planning framework follows a systematic approach, as shown in Figure 16

Figure 17: Approach to WWMA Adaptation Planning



The Adaptation Action Plan for Tema Metropolitan Assembly (TMA) focuses on several key areas:

- **Risk Assessment and Vulnerability Analysis:** Identifying the most significant climate risks and vulnerable sectors within the metropolis.
- **Stakeholder Engagement:** Involving local communities, government agencies, and other stakeholders in the planning process to ensure inclusive and effective adaptation strategies.
- **Implementation of Adaptation Measures:** Developing and executing specific actions to mitigate identified risks, such as improving drainage systems, enhancing green spaces, and promoting sustainable land use practices.
- **Monitoring and Evaluation:** Establishing mechanisms to track the progress and effectiveness of adaptation measures, allowing for adjustments and improvements over time.

9.2 Identification and Compilation of Sector-Specific Adaptation Actions

Expected Outcomes

Through the adaptation plan, underpinned by the evidence provided in the Tema Metropolitan Assembly Vulnerability Assessment (VA), the Assembly will:

- Address critical climate risks promptly and efficiently by identifying adaptation measures that are effective, cost-efficient, and measurable.
- Develop both short- and long-term business and operational plans informed by the vulnerability assessment.
- Strengthen the TMA's ability to manage the complex challenges and opportunities presented by climate change.
- Establish a clear and actionable adaptation plan with well-assessed options for implementation.

- Ensure alignment between the adaptation plan and the priority actions outlined in the TMA's Medium-Term Development Plans (MTDP) to address current and future needs.

Time Frame

The implementation of the Tema Metropolitan Assembly Adaptation Plan is set for the period 2024–2030, aligning with Ghana's revised Nationally Determined Contribution (NDC) timeframe (2020–2030). This period also corresponds with the next iteration of the TMA's MTDP (2025–2030), offering a unique opportunity to integrate the adaptation strategy within the Assembly's policies, programs, and activities.

Guiding Principles

Alignment with Ghana's NAP Process: The National Adaptation Plan (NAP) Framework provides the foundation for climate change adaptation in Ghana. The NAP process identifies key stakeholders and agencies, including the Ministry of Food and Agriculture (MoFA), to ensure coordinated efforts.

Gender Responsiveness: In Ghana, gender is recognized as a socially constructed concept, encompassing women, children, youth, and persons with disabilities. These groups, due to their heightened vulnerability to climate change, were a central focus in the development of this plan.

Nature-Based Solutions: Increasingly recognized for their environmental benefits, nature-based solutions are emphasized in this plan as effective strategies for enhancing resilience to climate change.

Science-Driven: Adaptation strategies are based on a solid understanding of current and future climate impacts, underpinned by scientific assessments of vulnerabilities and a comprehensive vulnerability assessment process.

Incorporation of Traditional Knowledge: The plan places a significant focus on integrating traditional and indigenous knowledge, particularly in selecting adaptation options, ensuring that local expertise contributes to effective solutions.

Participatory, Inclusive, and Locally Led: In line with the Ghana NAP framework, the development of this plan involved extensive participatory processes to ensure local ownership, with active involvement of the community throughout the assessment and planning stages.

Alignment with SDGs and National Goals: The adaptation plan aims to align with the United Nations Sustainable Development Goals (SDGs) and national development priorities. Efforts have been made to minimize trade-offs and maximize synergies between climate adaptation actions and development goals.

9.3 Institutional Arrangements and Metropolitan Level Adaptation Governance

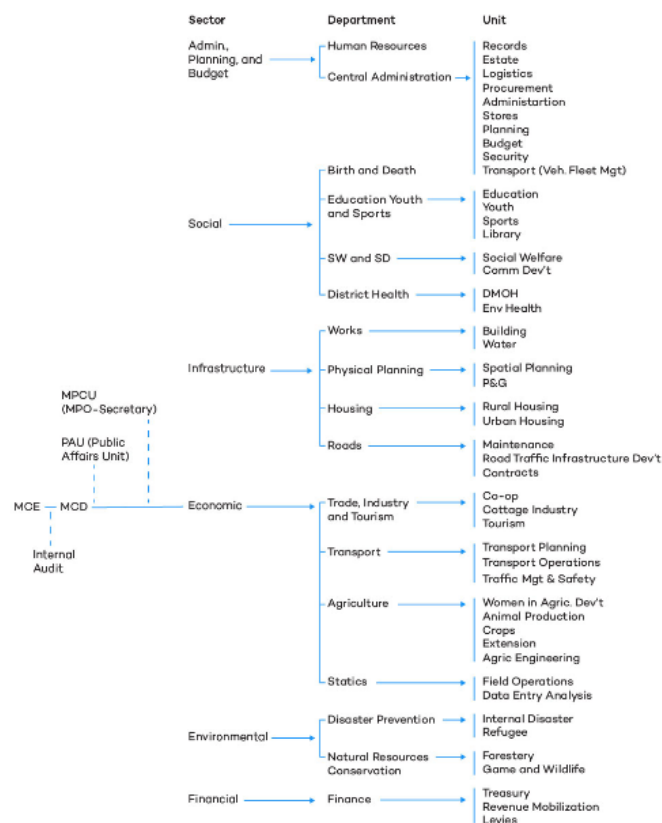
Proposed Arrangements for Adaptation Governance

Since 1988, Ghana has implemented a decentralization policy aimed at shifting development planning to the local level, ensuring alignment with the central government. This approach is designed to address community-specific needs while mobilizing local resources to contribute to the broader national development objectives.

According to Section 12 of Ghana's Local Governance Act of 2016, Metropolitan, Municipal, and District Assemblies (MMDAs) are responsible for developing plans that steer local growth. These assemblies function as the primary political, administrative, and planning entities in their respective regions.

The Tema Metropolitan Assembly's Medium-Term Development Plans (MTDPs) serve as comprehensive blueprints for local development. They outline the key programs and projects within the Metropolitan area over a three-year period, integrating activities from various departments, units, and stakeholders within the Assembly. Figure 17 illustrates the current governance framework of the Tema Metropolitan Assembly.

Figure 18: Metropolitan department's organogram

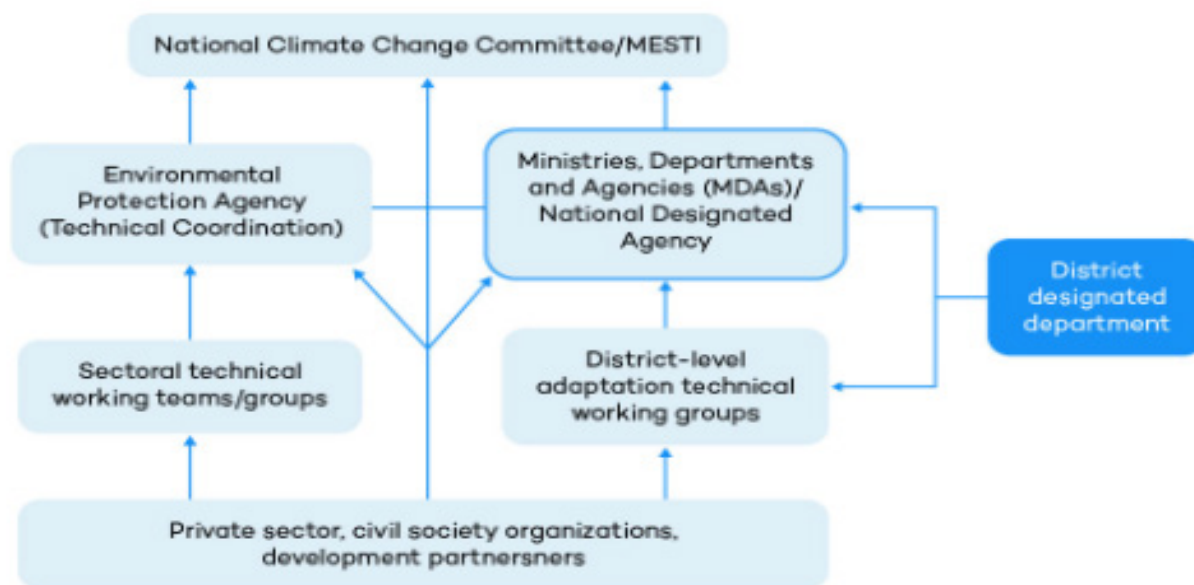


Source: TMA MTDP

To effectively integrate climate change into the governance of Tema Metropolitan Assembly (TMA), its structure must align with the national framework outlined in the National Adaptation Plan (NAP) (EPA, 2018). This alignment ensures that the TMA remains connected to the national climate change efforts through key Ministries, Departments, and Agencies (MDAs), as shown in the organogram in Figure 4. Climate change presents a relatively new challenge for many local governments, and there is uncertainty within the TMA regarding which department should take the lead on climate action. This lack of clarity can hinder effective leadership and the long-term success of adaptation strategies.

Under the NAP framework, the Environmental Protection Agency (EPA) is responsible for coordinating the development of a national adaptation plan, which includes key sectors such as agriculture, forestry, water, energy, health, and gender. On the other hand, the National Development Planning Commission (NDPC) supervises the adaptation planning process at the local level, ensuring these plans are integrated into the broader development goals. Establishing a dedicated department within the TMA to coordinate climate action will enhance the integration and efficiency of climate efforts at the local level. In this regard, the Metropolitan Planning Coordination Unit (MPCU) has been assigned the role of leading the implementation of the adaptation plan, with the establishment of a climate change desk within the Assembly. This initiative marks a significant step as the first of its kind at the subnational level in Ghana.

Figure 19: Proposed institutional arrangement for Ghana's NAP, including the role of the Metropolitan designated lead department



Source: Adapted from Figure 1 in Ghana's NAP Framework (EPA, 2018, p. 18)

9.4 Methodological Approach for Ranking Adaptation Options

9.4.1 Adaptation Plan Development Process

The development of the adaptation plan for the Tema Metropolitan Assembly (TMA) followed a structured, three-stage approach, illustrated in **figure 19**. This approach ensures that the plan remains responsive and adaptable over time, incorporating stages from problem definition to implementation, monitoring, evaluation, and learning. The key stages of this process included:

- **Desk Review:** An initial review of existing data and literature to assess the context and identify relevant issues.
- **Stakeholder Consultations:** Engaging local stakeholders in discussions to gather input and perspectives, ensuring the plan reflects the needs of the community.
- **Metropolitan Validation:** A final validation stage with local stakeholders to ensure the plan is comprehensive, applicable, and relevant to the needs of Tema.

Figure 20: Development Process of Adaptation Plan



Source: Author diagram.

Phase I: Comprehensive Review

Phase I consisted of an in-depth review of adaptation priorities and strategies identified in key national and sectoral climate change documents, including those from the Ministry of Environment, Science, Technology, and Innovation (MESTI) (2013, 2015), the Tema Metropolitan Assembly's Medium-Term Development Plan (MTDP), the Tema 2023 Annual Action Plan, academic literature, and insights from the Metropolitan-specific Vulnerability Assessment (VA). This review ensured the plan was firmly grounded in scientific evidence while aligning with both national and local priorities, as reflected in the MTDP. The insights gathered were pivotal in compiling a catalogue of sector-specific adaptation actions tailored to the context of Tema.

Phase II: Stakeholder Consultation and Evaluation

In Phase II, initial adaptation options proposed by consultants were evaluated through a participatory multi-criteria analysis. This process took place in specialized workshops organized within the Metropolitan. Five expert stakeholder groups participated in evaluating and analysing adaptation options within the following priority sectors:

- Agriculture
- Cities and Urban Land Use
- Disaster Risk Reduction
- Health
- Biodiversity
- Gender
- Water resources and water systems

Each consultation group included key representatives from TMA departments, non-governmental organizations (NGOs), the private sector, gender groups (youth, women, persons with disabilities), traditional leaders, farmer organizations, and the media. The vulnerability assessment provided the foundation for generating potential adaptation options, which were then presented during the stakeholder consultation workshop.

The primary objectives of the consultations were to:

- Provide a clear explanation of the adaptation planning process;
- Present and facilitate the review, screening, evaluation, and ranking of proposed adaptation options;
- Collect valuable feedback and perspectives from stakeholders on the proposed options;
- Discuss potential implementation strategies and approaches.

The Tema Metropolitan Assembly's climate change adaptation action plan involved identifying and compiling adaptation options specific to the metropolitan area. This approach enabled the exploration of various potential strategies and the identification of appropriate actions. The planning team used the methods described in Table 6 to guide the selection of these adaptation options.

Consultation with the sector stakeholders for the ranking and prioritization exercise



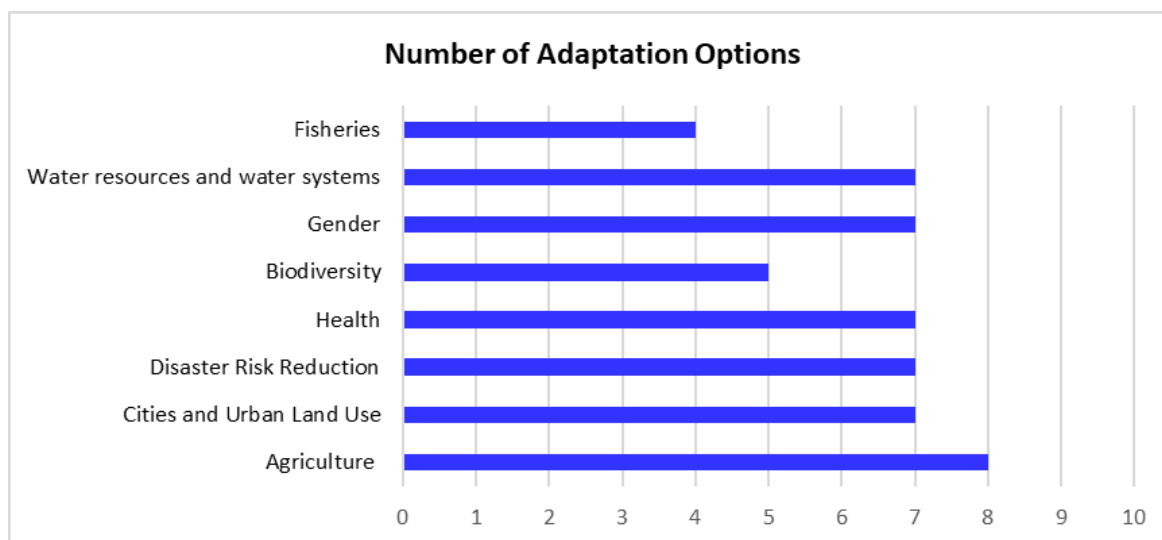
Table 6: Methodology to identify adaptation options.

Input Source	Description
 Vulnerability Assessment Report Recommendations	The climate change vulnerability assessment for the Tema Metropolitan Assembly provided specific recommendations on adaptation measures. These suggestions aim to strengthen resilience, boost adaptive capacity, and lower vulnerabilities. They were thoroughly integrated into the planning process.
 Literature Review	A comprehensive review of effective solutions and practices was conducted. This included a desk review of government reports, scientific studies, grey literature, and Metropolitan documents to pinpoint adaptation strategies that address similar climate impacts and vulnerabilities.
 Stakeholder Consultation	Identified stakeholders were actively engaged through participatory workshops, allowing open, inclusive discussions on adaptation options based on climate scenarios and current and projected impacts.

Source: Author diagram based on the TMA Adaptation Plan.

The measures discussed in Figure 6 were utilized to create a catalogue of relevant adaptation options presented in the tables in Appendix B. Overall, 52 adaptation options were identified across seven sectors: agriculture, biodiversity, water resources, health, DRR cities and urban land use, water resources and water systems, gender and fisheries. The distribution of the identified actions is illustrated in Figure 20.

Figure 21: Distribution of adaptation actions by sector



Source: Author diagram based on the TMA Adaptation Plan

9.4. 2 Adaptation Assessment Criteria

After identifying and compiling 52 potential adaptation options, the next step for the Tema Metropolitan Assembly was to evaluate and prioritize them using clearly defined criteria and information. This evaluation focused on assessing each option's relevance to the specific context of the Tema Metropolitan Assembly, its potential to improve resilience and address vulnerabilities identified in the vulnerability assessment, and its overall contribution to sustainable development. The prioritization process aimed to ensure informed decision-making, promoting effective adaptation while avoiding maladaptation. To ensure that the selected options were appropriate and did not lead to negative outcomes, relevant actors and stakeholders were involved in the process.

Stakeholders were organized into six groups—Agriculture and Biodiversity, Water Resources, Health and Sanitation, DRR and Cities and Urban Land Use, and Gender—and conducted a screening of the proposed options using a multicriteria analysis (MCA) (see Appendix A). This approach was essential because each adaptation option may perform differently across multiple criteria and involve trade-offs. As a result, a thorough evaluation of these options was necessary, and the findings from the MCA were integrated into the decision-making process for determining priority actions.

MCA, or multi-objective decision-making, is a tool used when traditional single-criterion methods, like cost-benefit analysis, cannot capture all relevant factors, especially when environmental and social impacts are significant but cannot be monetized. MCA provides a framework for assessing a wide range of criteria, including social, environmental, technical, economic, and financial considerations (Ngara, 2011). In this method, desired outcomes are clearly defined, and appropriate attributes or indicators are established. The evaluation of these indicators incorporates both quantitative approaches, such as scoring and ranking, as well as qualitative assessments of impacts. The criteria used for evaluating adaptation options are detailed in Table 6

Table 7: Criteria for assessment of adaptation actions

Criteria	Description
Adaptation Type	Assesses the risk reduction or risk transfer potential of an adaptation option. For instance, an irrigation system reduces drought risk, while crop insurance transfers it.
Implementation Level	Identifies the implementation scale of an adaptation, which could be community, Metropolitan/government, or autonomous.
Risk Gradient	Determines if the adaptation option is “risk-specific” (only effective if a particular risk occurs) or has broader applicability. Risk-specific options, like crop insurance, are beneficial only when certain impacts materialize, while others, such as post-harvest loss technology, are useful continuously.
SDGs and Development Co-benefit	Evaluates alignment of Metropolitan development programs with Sustainable Development Goals (SDGs) for additional benefits.
Risk Mitigation Potential	Assesses the option’s effectiveness in reducing specific climate risks.
Upscaling and Replicability Potential	Examines the potential to expand or replicate an adaptation intervention.
Cost-effectiveness	Evaluates cost-effectiveness for planning and implementing the adaptation measure.
Social and Cultural Acceptance	Ensures local buy-in by assessing the social and cultural acceptance of the project.
Cross-sectoral Maladaptation	Evaluates if an adaptation option might unintentionally harm other sectors.
Deliverability and Feasibility	Assesses the overall practicality and feasibility of the adaptation option.
Technical Feasibility	Determines if the necessary technical knowledge and capacity for implementing the adaptation measure are available.
Governance Implications	Evaluates if the adaptation aligns with current governance structures or if it requires modifications or new governance frameworks.
Social Considerations	Considers the impact of the adaptation measure on social inclusion and community cohesion.
Environmental Considerations	Assesses potential benefits for GHG reduction, biodiversity, human health, soil and water quality, air quality, climate, and landscapes.
Stakeholder Interest	Gauges the level of stakeholder support for the adaptation measure.
Potential Negative Outcomes	Identifies possible adverse effects from implementing the adaptation option.
Barriers to Implementation	Highlights potential institutional, economic, or social obstacles to implementing the adaptation option.

Source: Author diagram based on TMA Adaptation Plan.

As detailed in Appendix B, indicators for each criterion were developed and applied using scoring, ranking, and weighting methods. During sector group consultations, stakeholders ranked the criteria for each of the 44 adaptation options identified. The results of this thorough assessment can be found in Appendix A. The outcomes of the multicriteria analysis (MCA) provided key inputs for selecting adaptation options to advance into concrete actions, with the final choices based on the aggregated scores from the sum of variables for each indicator. Additionally, expert judgment, insights from the literature review, and consultations with authorities from the Tema Metropolitan Assembly (TMA) and the Environmental Protection Agency (EPA) helped guide the selection of priority adaptation options.

In each sector, about half of the proposed actions were prioritized for further development and implementation. The selection of these priority actions was determined by assessing the vulnerability and significance of each sector within the Tema Metropolitan Assembly, as well as ensuring that the actions aligned with the TMA's development goals outlined in the MTDP 2022–2025.

9.5 Adaptation options

This section describes the prioritized climate change adaptation options, highlighting each option's adaptation objective, justification, and critical considerations.

9.5.1 Agriculture

According to the Tema Metropolitan Assembly Vulnerability Assessment, agriculture is identified as a key vulnerable sector which requires significant attention. The 8 adaptation actions that were identified and assessed through the multicriteria analysis (MCA), are discussed below. These actions target largely small-scale farmers who currently depend on rain-fed agriculture and are designed to enhance or maintain agricultural productivity in the face of climate change. The adaptation objectives, justifications, and estimated implementation costs for each of these actions are further elaborated upon.

Agroforestry is an effective approach to enhancing agricultural productivity and building resilience against climate impacts, especially in areas where agriculture is a primary livelihood. By integrating trees, crops, and livestock, it improves soil health, conserves water, protects biodiversity, and captures carbon. These practices contribute to sustainable food systems, better livelihoods, and reduced environmental degradation. Training and educating farmers on agroforestry and sustainable agriculture are essential to help them adapt to challenges like climate change and food insecurity. Early warning and response systems play a key role in reducing the effects of climate-related events on agriculture. Timely information allows farmers to make informed decisions, minimizing crop losses, reducing economic hardships, and supporting food security. Preparedness through these systems strengthens communities' ability to handle both immediate and long-term climate challenges. Diversifying agricultural livelihoods helps reduce dependence on a single crop or activity, providing stability in income and food security while building resilience to climate variability and market changes. Broadening livelihood options creates sustainable opportunities and supports long-term development.

Conservation agriculture improves soil fertility, reduces water runoff, and enhances carbon sequestration, mitigating the effects of climate change. These practices boost productivity, reduce reliance on chemical inputs, and promote sustainable land management. This balance between productivity and environmental conservation supports long-term agricultural sustainability. Climate-resilient crop varieties, such as drought-tolerant and pest-resistant types, enable farmers to maintain yields during extreme weather conditions. These crops contribute to food security, economic stability, and long-term sustainability. Efficient irrigation systems improve agricultural productivity in water-scarce regions by ensuring consistent crop yields and reducing reliance on rainfall. Sustainable irrigation practices help conserve water, protect the environment, and support livelihoods in areas affected by climate change.

Table 8: Ranking of adaptation options for the agriculture sector

Agriculture and food security	Final score	Rank
Agroforestry	48	1
Sensitization and training	45	2
Early Warning and Response Mechanisms	44	3

Diversification of Livelihoods	43	4
Conservation Agriculture	42	5
Use Climate Resilient Crop Varieties	42	5
Irrigation Systems	39	7
Afforestation	15	8

Table 9: Summary of the Adaptation Actions for the Agricultural Sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Conservation Agriculture	The objective is to promote Conservation Agriculture as a sustainable farming approach that improves soil health, reduces erosion, enhances water efficiency, and increases climate resilience. This initiative aims to support farmers in adopting minimal soil disturbance, crop rotation, and cover cropping practices to enhance long-term agricultural productivity and sustainability.	□ Identify and promote cover crops suited to local climate and soil conditions for soil protection and organic matter. □ Raise awareness about the long-term benefits of conservation agriculture (CA) for soil health, including no-till farming and residue retention. □ Facilitate affordable access to CA-specific equipment through subsidies, rental programs, or cooperatives. □ Establish demonstration plots to showcase CA effectiveness and encourage peer learning. □ Provide financial or in-kind incentives, such as grants, input vouchers, or recognition programs, for early adopters of CA practices. □ Incorporate traditional soil management practices that complement CA principles. □ Offer technical assistance on crop rotation planning to maximize soil fertility and pest control.	Short-term	Human Finance Technology	TMA	MOFA MESTI Agric Extension Agents (AEAs) Farmer Cooperatives and Community Groups Research Institutions and Universities Non-Governmental Organizations (NGOs) Private Sector Companies – including Local Markets and Retailers Development Partners and Donors	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Early warning and response mechanisms	The objective is to establish and strengthen Early Warning and Response Mechanisms (EWRM) to protect agricultural communities from climate-related risks, including droughts, floods, and pest infestations.	□ Ensure early warning information is accessible to all farmers through methods like radio alerts, SMS, and local announcement boards. □ Provide training to farmers on how to respond to various alerts, such as crop protection or pest control. □ Utilize local knowledge and data to enhance the accuracy of warnings, incorporating regional weather patterns and potential climate impacts. □ Integrate traditional knowledge on weather patterns and seasonal changes to improve warning accuracy and build trust. □ Strengthen collaboration with municipal authorities, disaster management agencies, and agricultural extension services for prompt responses. □ Develop scalable response strategies based on event severity, from minor advisories to full emergency mobilization. □ Ensure warnings are concise, understandable, and free of technical jargon to improve effectiveness. □ Prioritize vulnerable groups such as small-scale farmers, women, and the elderly in response measures.	Medium-term	Human Technical / Technology Finance	MESTI	MoFA GMET NGOs Research Institutions Private Sector Technology Providers, Mobile Network Operators and ICT Providers Community-Based Organizations (CBOs) Farmer Associations and Cooperatives Media Outlets (Local Radio and TV) Educational Institutions NADMO Women's Cooperatives and Youth Groups Traditional and Local Leaders	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Diversification of livelihoods	The objective is to promote the diversification of agricultural livelihoods, enabling farmers to engage in multiple income-generating activities that increase resilience to climate and market shocks. This strategy aims to reduce farmers' vulnerability to crop failure, fluctuating prices, and other risks by providing alternative sources of income.	□ Ensure farmers have access to reliable markets for diversified products, including livestock, processed goods, or crafts. □ Create linkages with buyers or cooperatives to enhance profitability of diversified activities. □ Provide targeted training for farmers to develop skills relevant to new income-generating activities. □ Support farmers with access to affordable inputs, credit, and resources for diversified activities. □ Foster community-based enterprises that encourage cooperation, shared resources, and collective marketing. □ Promote livelihood options aligned with seasonal agricultural cycles to balance time effectively. □ Educate farmers on assessing and managing risks associated with new livelihoods. □ Ensure that diversification options are accessible and beneficial to both men and women, with specific support for women.	Short term	Human Technology Finance	TMA	Local Government Institutions. Non-Governmental Organizations (NGOs) Financial Institutions (Microfinance and Savings Schemes) Development Partners, Donors, International Organizations (e.g., UNDP, FAO) Private Sector Farmer Cooperatives and Women's Groups Educational and Vocational Training Institutions Traditional and Local Leaders Research Institutions	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
						Business Development Organizations Community-Based Organizations (CBOs)	
Irrigation systems	To enhance the adoption and effective utilization of irrigation systems in agriculture, ensuring increased agricultural productivity, resilience to climate variability, and sustainable resource management.	□ Implement efficient water management practices, including scheduling irrigation based on soil moisture levels. □ Integrate modern technologies such as soil moisture sensors and automated irrigation systems to optimize water usage. □ Provide comprehensive training for farmers on the maintenance and operation of irrigation systems. □ Invest in necessary infrastructure such as canals, pumps, and storage facilities for reliable water delivery. □	Medium term	Human Technology Finance	MoFA	TMA NGOs Agricultural Extension Agencies Microfinance Institutions and Cooperatives Private Sector Companies – For supplying irrigation technologies (e.g., solar pumps, drip systems) and maintenance services.	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Foster community involvement in the planning and execution of irrigation projects. □ Promote research into new irrigation methods to enhance water efficiency and crop yields. □ Establish systems for ongoing monitoring and evaluation of irrigation practices. □ Conduct assessments to evaluate the long-term sustainability of irrigation practices.				International Development Agencies (e.g., FAO, UNDP, World Bank) Research Institutions (e.g., CSIR-Ghana, universities) Traditional and Community Leaders Community-Based Organizations (CBOs) Women's Groups and Cooperatives	
Agroforestry	The objective is to promote and enhance the adoption and sustainable management of agroforestry systems as a multifunctional land-use approach that supports agricultural productivity, climate resilience, and ecosystem health.	□ Selection of suitable tree species well-suited to local environmental conditions and complementary to crops or livestock. □ Involvement of local farmers in planning, decision-making, and implementation to foster ownership and responsibility. □ Provision of training programs to equip farmers with knowledge on tree management, intercropping, and sustainable land use practices.	Medium term	Human Technology Finance	MoFA	TMA IUCN UNDP Agricultural Extension Agents Microfinance Institutions and Cooperatives	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
	This initiative aims to integrate agroforestry practices that align with local agricultural needs, community priorities, and sustainable resource management principles.	□ Access to financial resources such as subsidies, grants, or low-interest loans to overcome initial cost barriers. □ Ongoing monitoring and evaluation to assess performance, measure success, and guide adjustments for efficiency. □ Designing agroforestry systems with flexibility to adapt to changing climate conditions, using resilient species and sustainable practices. □ Establishment of supportive policies and institutional frameworks to promote agroforestry, provide technical support, and ensure market access.				Private Sector Companies Research Institutions (e.g., CSIR-Ghana, universities). NGOs (e.g., CARE, ActionAid). Development Banks (e.g., African Development Bank, World Bank). Agricultural Technology Providers. Women's Groups and Cooperatives	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Use Climate Resilient Crop Varieties	Enhance agricultural resilience and ensure food security.	□ Select crop varieties adapted to local climate conditions and soil types to maximize resilience and productivity. □ Ensure climate-resilient seeds are readily available and affordable through partnerships with seed banks, agricultural agencies, or cooperatives. □ Provide training on cultivation practices tailored to climate-resilient varieties. □ Establish demonstration plots to showcase the performance of climate-resilient crops. □ Offer subsidies, loans, or other incentives to lower the cost barriers for transitioning to climate-resilient crop varieties. □ Promote awareness and involve community leaders to enhance acceptance of climate-resilient crops. □ Prioritize climate-resilient crops that provide both high nutritional and market value.	Short term	Human Technology Finance	MoFA	TMA EPA FAO UNDP Research Institutions (e.g., KNUST) Private Sector	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Sensitization and training	The objective is to enhance farmers' awareness and capacity through sensitization and training programs, enabling them to adopt improved agricultural practices, increase resilience to climate change, and effectively manage resources. These initiatives aim to equip farmers with knowledge and skills relevant to sustainable agriculture, climate adaptation, and modern farming techniques.	□ Ensure training materials and messaging are specific to the local agricultural context, addressing crop types, pest issues, and seasonal weather patterns. □ Use practical, hands-on training sessions with demonstration plots, farmer field schools, and interactive workshops. □ Conduct sessions in local languages with accessible materials for varying literacy levels, using visuals and straightforward language. □ Implement a follow-up system with community-based mentors or regular check-ins for continued support. □ Set up feedback mechanisms to adjust training content and approach based on community needs. □ Highlight successful case studies from nearby communities to encourage adoption. □ Develop strategies to engage younger community members, including tech-based agriculture modules.	Short term	Human Technology Finance	TMA	NGOs Private Sector Partners (e.g., technology providers, financial institutions) Agricultural Extension Agents Research and Development Institutions Financial Institutions (e.g., microfinance banks, cooperatives) Local farmer cooperatives and associations	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Afforestation	To promote afforestation practices that enhance agricultural productivity, restore degraded lands, and contribute to environmental sustainability.	□ Develop afforestation strategies that complement existing agricultural practices, such as agroforestry. □ Ensure flexibility in afforestation approaches to adapt to local conditions and farmer preferences. □ Select tree species that enhance soil health, prevent erosion, and promote biodiversity. □ Prioritize the use of native tree species to enhance ecological balance and resilience. □ Engage local communities in the planning and implementation of afforestation projects. □ Foster collaboration between government, NGOs, and the private sector to support afforestation efforts. □ Explore economic incentives, such as carbon credits or grants, to encourage farmer participation. □ Raise awareness about the benefits of afforestation and provide education on best practices.	Short-term	Human Technology Finance	TMA	Private sector companies Financial institutions Development partners (e.g., UNDP, World Bank, etc) NGOs Local communities MESTI Forestry commission Local farmers and community leaders Educational institutions (e.g., schools, universities)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME Short, Medium, or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		▫ Implement monitoring systems to assess the ecosystem services provided by afforestation. ▫ Invest in research to understand the long-term impacts of afforestation on agricultural systems.				Private sector (e.g., eco-tourism operators, agroforestry businesses)	

9.5.2 Cities and land use

According to the Tema Metropolitan Assembly Vulnerability Assessment, cities and urban land use sector need focused adaptation measures. Seven adaptation actions were identified and assessed through multicriteria analysis (MCA). To guide effective adaptation planning, effective urban planning and development require a combination of strategies to address climate change, manage growth, and enhance sustainability. Building proper drainage systems prevents flooding, protects infrastructure, and improves public health. Updating zoning laws and enforcing bye-laws ensures responsible land use, curbs urban sprawl, and promotes liveable, inclusive communities.

Early warning systems help mitigate natural hazards by guiding risk-aware development and improving urban resilience. Investments in resilient infrastructure and housing address growing urban demands while ensuring accessibility, sustainability, and equity. Restoring wetlands enhances biodiversity, manages stormwater, and supports climate adaptation. Together, these measures foster sustainable, well-managed urban environments.

Table 10: Ranking of adaptation options for the Cities and land use

Cities and land use	Final score	Rank
Construction of Improved Drainage Systems	46	1
Improve zoning laws	42	2
Early Warning and Response Mechanisms	39	3
Improved Infrastructure	39	3
Provision of accommodation	38	5
Wetlands restoration	37	6
Strict enforcement of bye-laws	35	7

Table 11: Summary of the Adaptation Actions for the Cities and land use Sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Construction of Improved Drainage Systems	To construct improved drainage systems that enhance urban resilience, manage storm water effectively, and mitigate flooding, thereby promoting sustainable land use and improving overall urban living conditions.	□ Integrate drainage system designs into broader urban planning frameworks, considering land use and growth projections. □ Promote green infrastructure techniques, such as permeable pavements and bio-swales, for enhanced drainage effectiveness. □ Engage local communities in the planning and implementation of drainage projects to ensure systems meet local needs. □ Conduct cost-benefit analyses to assess the economic viability of drainage projects. □ Develop and enforce regulations to guide drainage system design and maintenance, ensuring environmental compliance. □ Provide training for municipal staff and local contractors on drainage technologies and management practices.	Long term	Human Technology Finance	TMA MSWR	Private sector Academic and Research Institutions Philanthropic organizations WWF Ghana Nature Conservation Research Centre (NCRC) UN-Habitat, World Bank, USAID MESTI Traditional Authorities Local Farmer Groups and Cooperatives Private Sector Partners CSOs/NGOs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Design drainage systems with climate resilience in mind, accounting for changes in rainfall and urban heat. □ Establish ongoing monitoring and maintenance plans for effective drainage system operation. □ Ensure equitable access to improved drainage systems across different socio-economic groups. □ Foster partnerships among government, NGOs, and the private sector to leverage resources for drainage system construction and maintenance.					
Improve zoning laws	To enhance zoning laws that promote sustainable land use, facilitate urban development, and ensure equitable access to resources and opportunities in cities.	□ Actively involve local communities in the zoning law revision process to ensure regulations reflect their needs and values. □ Consider traditional land use practices and cultural heritage in zoning law revisions. □ Incorporate sustainability principles into zoning laws to protect natural resources, enhance biodiversity, and reduce carbon footprints. □ Design zoning regulations that allow for flexibility and adaptability to accommodate changing urban dynamics.	Medium-term	Human Technology Finance	TMA	Private sector companies Financial institutions Development partners (e.g., UNDP, World Bank, etc) NGOs Local communities MESTI Forestry commission	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Conduct economic impact assessments to evaluate the potential effects of zoning changes on local economies. □ Assess and empower local authorities to ensure they have the capacity to enforce new zoning regulations effectively. □ Address equity concerns in zoning regulations, ensuring access to land and resources for marginalized groups. □ Foster partnerships among government, community organizations, and private stakeholders for effective zoning regulation implementation and enforcement.				Local farmers and community leaders Educational institutions (e.g., schools, universities) Private sector (e.g., eco-tourism operators, agroforestry businesses) Public-Private Partnerships (PPPs) (e.g., collaborative projects between government and private sector)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Early Warning and Response Mechanisms	To establish and enhance early warning and response mechanisms that improve urban resilience, facilitate timely disaster responses, and ensure effective land use planning in cities.	□ Integrate data from various sources (meteorological, geological, social) for comprehensive risk assessments and timely alerts. □ Engage local communities in the development and implementation of early warning systems to ensure relevance and accessibility. □ Implement public awareness campaigns to educate residents about early warning systems and emergency procedures. □ Provide training for municipal staff, emergency responders, and community leaders on using and managing early warning systems. □ Invest in necessary infrastructure for effective early warning systems, including communication technologies and monitoring stations. □ Conduct cost-benefit analyses to evaluate the economic viability of early warning initiatives. □ Design early warning systems to be flexible and adaptable to changing urban conditions and emerging risks. □	Medium-term	Human Technology Finance	TMA GMeT	EPA NADMO Private sector companies Financial institutions Development partners (e.g., UNDP, AfDB, etc) NGOs Academic and Research Institutions Philanthropic organizations Local community-based organizations Local government agencies Traditional leaders and local community groups	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Ensure early warning mechanisms align with broader municipal strategies for disaster risk reduction, urban planning, and climate resilience. □ Establish monitoring and evaluation frameworks to assess the effectiveness of early warning systems. □ Address the specific vulnerabilities of men and women in disaster contexts by ensuring the system meets all community members' needs.				Educational institutions (for public awareness campaigns) International development organizations	
Improved Infrastructure	To enhance urban infrastructure that supports sustainable land use, improves accessibility, and promotes the overall quality of life in cities.	□ Integrate infrastructure development with urban planning, considering future growth, land use, and community needs. □ Promote the use of sustainable materials and construction practices to minimize environmental impacts. □ Design infrastructure with climate resilience in mind to withstand extreme weather and changing conditions. □ Involve local communities in the planning and decision-making processes for infrastructure projects. □ Assess the affordability of infrastructure projects to ensure good value for investment.	Long-term	Human Technology Finance	TMA Ministry of works and Housing	Private sector companies Financial institutions Development partners Academic and Research Institutions NADMO EPA Forestry Commission	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Ensure infrastructure is accessible to all community members, supporting social equity. □ Consider institutional capacity for maintaining and operating improved infrastructure for long-term sustainability. □ Implement flexible infrastructure designs that can adapt to changing urban needs and advancements. □ Establish systems for monitoring and evaluating infrastructure projects to assess effectiveness and inform future developments. □ Foster partnerships among government, private sector, and community organizations for infrastructure development.				Local community groups and traditional leaders NGOs such as International organizations (e.g., UN Environment Programme, Global Environment Facility) Conservation Trust Funds and financial institutions	
Provision of accommodation	To enhance the provision of diverse and affordable accommodation options that meet the needs of urban populations while promoting sustainable land use and community development.	□ Develop policies prioritizing affordable housing initiatives for low- and middle-income residents. □ Involve local communities in the planning process to ensure accommodation solutions reflect their needs and preferences. □ Review and adapt zoning laws to facilitate diverse housing types and reduce barriers to affordable accommodation development.	Long-term	Human Technology Finance	TMA Ministry of works and housing	MoFA MESTI Private sector companies Development partners NGOs CSOs CBOs,	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Integrate new accommodation developments with essential services (e.g., schools, healthcare, transportation). □ Design flexible housing policies that adapt to changing market demands and population dynamics. □ Establish mechanisms for monitoring housing development outcomes and making adjustments based on feedback and conditions. □ Address equity in housing provision by prioritizing accommodations for marginalized and underserved populations.				Academic and Research Institutions Financial Institutions (for microcredit and loans)	
Wetlands restoration	To promote the restoration of urban wetlands to enhance ecological integrity, improve urban resilience, and support sustainable land use practices	□ Employ science-based restoration techniques focusing on native plant species and natural hydrology. □ Integrate wetland restoration efforts into broader urban planning frameworks. □ Engage local communities in the planning and implementation of restoration projects. □ Collaborate with governmental agencies, NGOs, and academic institutions to leverage resources.	Medium term	Human Technology Finance	TMA	EPA NADMO Private sector companies Financial institutions Development partners (e.g., UNDP, AfDB, etc) NGOs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Implement educational programs to inform residents about the benefits of wetlands. □ Design restoration projects with climate resilience to enhance adaptation and mitigate flood risks. □ Establish monitoring systems to evaluate the success of restoration efforts and adapt management practices. □ Assess the affordability of restoration initiatives to avoid significant financial burdens. □ Incorporate traditional ecological knowledge from local communities for culturally appropriate practices. □ Ensure equitable access to restored wetlands for all community members, particularly marginalized populations				Academic and Research Institutions Philanthropic organizations Local community-based organizations Local government agencies Traditional leaders and local community groups Educational institutions (for public awareness campaigns) International development organizations	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Strict enforcement of bye-laws	To ensure the strict enforcement of bye-laws that govern land use and urban development, thereby promoting sustainable practices and enhancing the liveability of cities.	□ Stakeholder awareness of bye-laws and their implications. □ Public awareness campaigns promoting urban sustainability. □ Training and resources for local authorities and enforcement agencies. □ Community involvement in monitoring and reporting violations. □ Use of data and technology for targeted enforcement. □ Assessment of economic implications for residents and businesses. □ Alignment of bye-laws with broader municipal goals (e.g., sustainability, public health). □ Monitoring and regular assessment of compliance. □ Equitable application of enforcement measures across communities. □ Flexibility in enforcement approaches to ensure fairness.	Medium term	Human Technology Finance	TMA	EPA NADMO Private sector companies Financial institutions Development partners (e.g., UNDP, AfDB, etc) NGOs Academic and Research Institutions Philanthropic organizations Local community-based organizations Local government agencies Traditional leaders and local community groups	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
						Educational institutions (for public awareness campaigns) International development organizations	

9.5.3 Disaster Risk Reduction and Transport

The Tema Metropolitan Assembly faces a combination of high-impact climate vulnerabilities. Flooding, exacerbated by inadequate drainage systems, coastal erosion and extreme weather events, presents significant risks to both human life and property. Out of the seven adaptation actions that were identified and assessed through the MCA, five were selected and discussed below due to their cross cutting nature of the adaption option and its discussion in previous sectors. A financial assessment of all the options are however provided. Expanding drainage systems is essential for managing stormwater and reducing the risks of flooding and waterlogging in urban areas. Well-designed drainage systems protect infrastructure, prevent waterborne diseases, and enhance disaster preparedness. Prioritizing drainage improvements helps municipalities adapt to climate change, safeguard public safety, and support residents' well-being.

Community engagement and awareness are vital for effective disaster risk reduction. Informed and involved communities are better equipped to handle disasters, fostering collective action and stronger networks. Increased awareness leads to better decision-making, resource allocation, and resilience against natural hazards. Improved drainage systems are critical for managing heavy rainfall and reducing flooding risks in urban areas. These systems protect public health, maintain infrastructure, and support economic activities by ensuring accessibility. Investing in drainage infrastructure is key to addressing the challenges of climate change and more frequent extreme weather events. Water conservation practices are essential for mitigating drought and flooding. Efficient water use reduces scarcity risks during emergencies and minimizes runoff during heavy rainfall, lowering flood risks. These practices promote sustainability, reduce costs, and improve agricultural productivity, strengthening community resilience. Relocation is an effective strategy to protect populations at risk from environmental hazards like flooding or sea-level rise. Moving communities to safer areas safeguards lives, reduces economic losses, and enhances resilience. Successful relocation efforts consider long-term sustainability, ensuring access to essential services and livelihoods while involving communities in the process to build trust and ownership

Table 12: Ranking of adaptation options for the DRR sector

DRR	Final score	Rank
Afforestation	46	1
Expansion of Drainage Systems	43	3
Community Engagement and Awareness	42	3
Construction of Improved Drainage Systems	42	3
Water Conservation Practices	42	3
Early Warning and Response Mechanisms	40	6
Relocation	40	6

Table 13: Summary of the Adaptation Actions for the DRR Sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Water Conservation Practices	To promote water conservation practices as a critical strategy for disaster risk reduction, ensuring sustainable water management and enhancing resilience to water scarcity and flooding.	□ Implementing awareness campaigns on water conservation with practical tips for households and businesses. □ Engaging local communities in developing and implementing culturally relevant water conservation initiatives. □ Aligning water conservation practices with municipal water management policies for cohesive implementation. □ Promoting the adoption of water-saving technologies, such as drip irrigation, rainwater harvesting, and smart metering. □ Establishing incentive programs, like rebates or subsidies, for water-efficient appliances and fixtures. □ Creating systems to monitor water usage and conservation outcomes, providing feedback to stakeholders. □ Designing adaptable conservation practices to meet diverse community needs.	Short-term	Human Technology Finance	TMA	NADMO EPA Urban Planning and Development Partners CBOs NGOs Academic and Research Institutions Community leaders and traditional authorities Private sector partners (e.g., companies in water infrastructure and eco-tourism)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Collaborating with agricultural stakeholders to promote irrigation efficiency and reduce water consumption. - Conducting assessments to identify areas at risk from drought and flooding, prioritizing conservation efforts in these locations.					
Afforestation	To enhance disaster preparedness and community resilience in Tema through the establishment of disaster information groups that facilitate timely communication, effective response coordination, and community engagement in disaster risk reduction (DRR) efforts.	- Develop afforestation strategies that complement existing agricultural practices, such as agroforestry. - Ensure flexibility in afforestation approaches to adapt to local conditions and farmer preferences. - Select tree species that enhance soil health, prevent erosion, and promote biodiversity. - Prioritize the use of native tree species to enhance ecological balance and resilience. - Engage local communities in the planning and implementation of afforestation projects.	Short term	Human Technology Finance	TMA	NADMO Municipal Disaster Management Committee EPA CBOs NGOs Local Health Departments Academic and Research Institutions	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Foster collaboration between government, NGOs, and the private sector to support afforestation efforts. □ Explore economic incentives, such as carbon credits or grants, to encourage farmer participation. □ Raise awareness about the benefits of afforestation and provide education on best practices. □ Implement monitoring systems to assess the ecosystem services provided by afforestation. □ Invest in research to understand the long-term impacts of afforestation on agricultural systems.				Traditional Leaders and Community Elders Media Organizations International Development Partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Community Engagement and Awareness	To enhance community engagement and awareness in disaster risk reduction initiatives, fostering a culture of preparedness and resilience among local populations.	□ Development of education programs tailored to specific community risks, focusing on prevention, preparedness, and response. □ Incorporation of local knowledge and practices into disaster risk reduction strategies. □ Collaboration with local NGOs, community groups, and schools to expand outreach and engagement. □ Use of diverse communication channels (social media, community meetings, printed materials) to ensure accessibility. □ Provision of training for community leaders and volunteers to enhance disaster risk reduction capacity.	Short-term	Human Technology Finance	TMA	NADMO EPA CBOs NGOs Academic and Research Institutions Private Sector Professional Training Organizations International Development Partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Establishment of channels for community feedback and input on disaster risk reduction initiatives. □ Support for community-led disaster preparedness, response, and recovery initiatives. □ Integration of disaster risk reduction education into local cultural practices and events. □ Monitoring and evaluation of community engagement efforts for continuous improvement. □ Ensuring equitable access to disaster risk reduction information for marginalized and vulnerable groups.				Local media outlets (e.g., radio, social media) Traditional leadership structures	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Early Warning and Response Mechanisms	To enhance the effectiveness and operational capacity of the National Disaster Management Organization (NADMO) officials in Tema by providing incentives and support that motivate their performance in disaster risk reduction (DRR) initiatives.	□ Integrate data from various sources (meteorological, geological, social) for comprehensive risk assessments and timely alerts. □ Engage local communities in the development and implementation of early warning systems to ensure relevance and accessibility. □ Implement public awareness campaigns to educate residents about early warning systems and emergency procedures. □ Provide training for municipal staff, emergency responders, and community leaders on using and managing early warning systems. □ Invest in necessary infrastructure for effective early warning systems, including communication technologies and monitoring stations. □ Conduct cost-benefit analyses to evaluate the economic viability of early warning initiatives.	Medium-term	Human Technology Finance	TMA NADMO GMeT	EPA Forestry Commission NADMO CBOs NGOs CSOs Academic and Research Institutions International Disaster Response Agencies Local Educational Institutions and Training Providers	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Design early warning systems to be flexible and adaptable to changing urban conditions and emerging risks. □ Ensure early warning mechanisms align with broader municipal strategies for disaster risk reduction, urban planning, and climate resilience. □ Establish monitoring and evaluation frameworks to assess the effectiveness of early warning systems. □ Address the specific vulnerabilities of men and women in disaster contexts by ensuring the system meets all community members' needs.				Private Sector Partners (e.g., technology and equipment suppliers) United Nations Agencies (e.g., UNDP, UNICEF) Local community groups and leaders	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Expansion of Drainage Systems	To enhance the expansion of drainage systems in urban areas to effectively manage stormwater, reduce flooding, and mitigate the impacts of natural disasters.	- Thorough assessments identifying flood-prone areas for drainage system prioritization. - Integration of drainage system expansion into urban development plans. - Community involvement in the planning and decision-making process. - Use of sustainable drainage solutions (e.g., permeable pavements, green roofs, rain gardens). - Design of drainage systems considering future climate scenarios. - Financial assessment and exploration of funding mechanisms for drainage expansion.	Long-term	Human Technology Finance	NADMO	MESTI Forestry Commission EPA NADMO Local communities CBOs NGOs Academic and Research Institutions Private Sector International Development Partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Training and resources for municipal staff and contractors on drainage system management. □ Comprehensive monitoring and maintenance plans for drainage systems. □ Public education campaigns on the importance of drainage for disaster risk reduction. □ Equity considerations ensuring drainage projects benefit all community members, particularly marginalized groups.					
Relocation	To promote relocation as a strategic measure for disaster risk reduction, enabling communities at high risk of hazards to transition to safer environments and enhance their resilience to future disasters.	□ Conducting assessments to identify disaster-vulnerable areas and prioritize relocation based on risk levels. □ Involving affected communities in decision-making to ensure their needs, preferences, and cultural values are considered. □ Identifying relocation sites that offer safety from hazards and access to essential services (healthcare, education, employment). □ Providing financial assistance, subsidies, or incentives to support the transition and reduce economic burdens.	Medium-term	Human Technology Finance	TMA NADMO	MLGRD MESTI EPA NADMO CBOs NGOs Academic and Research Institutions Private Sector	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Developing necessary infrastructure (roads, utilities, housing) in new relocation areas. - Establishing legal frameworks and policies to protect displaced persons' rights and ensure fair compensation. - Recognizing and respecting cultural identities to support cultural continuity in relocation efforts.				International Development Partners	
Construction of Improved Drainage Systems	To promote the construction of improved drainage systems as a key strategy for disaster risk reduction, enhancing urban resilience and minimizing flood risks in vulnerable areas.	- Conducting detailed hydrological studies to understand local drainage patterns and identify flood-prone areas. - Involving local communities in the planning and design of drainage systems to ensure they meet local needs. - Aligning drainage system construction with broader urban planning efforts for compatibility with land use and infrastructure. - Evaluating the economic feasibility of drainage projects, considering costs, maintenance, and benefits. - Providing training and resources to local government officials and engineers to enhance technical capacity.	Long-term	Human Technology Finance	TMA	Ministry of roads and highways NADMO GMet EPA CBOs NGOs Academic and Research Institutions Media Organizations International Development partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Allowing flexibility in the design and implementation of drainage systems to adapt to changing conditions. □ Developing comprehensive monitoring and maintenance plans to ensure long-term functionality and address issues proactively.					

9.5.4 Health

Climate change adaptation options identified on human health in the TMA Metropolitan emanate from direct impacts of extreme events such as heatwaves and storms, and indirect impacts from its linkage to other sectors such as waste, sanitation, and agriculture (food insecurity). Four out of the seven identified adaptation actions have been selected and expanded on due on the interlinkages and discussions in other related sectors. Mangrove ecosystems are vital for coastal health, acting as natural storm barriers, improving water quality, and supporting biodiversity. They also play a key role in carbon sequestration, helping mitigate climate change. Restoring mangroves benefits the environment, enhances public health by reducing pollution, and provides resources for local communities.

Public health education campaigns raise awareness about health issues, promote preventive measures, and encourage healthier lifestyles. They empower communities with knowledge to make informed health decisions, reducing disease and improving quality of life. To address emerging health threats, these campaigns must remain adaptable and culturally relevant. Air quality monitoring helps identify pollution sources, assess health impacts, and guide actions to reduce air pollution. Poor air quality is linked to respiratory and cardiovascular issues. Effective monitoring systems enable communities to respond to pollution, adapt to environmental changes, and protect public health. Public health regulations are essential for preventing disease, protecting the environment, and promoting health equity. Well-designed regulations set health standards, encourage compliance, and ensure enforcement. Adapting regulations to local needs enhances health outcomes and strengthens public health systems.

Table 14: Ranking of adaptation options for the health sector

Health	Final score	Rank
Early warning systems	46	1
Construct and improve infrastructure	46	1
Afforestation	45	3
Mangrove restoration	45	3
Public Health Education Campaigns	44	5
Air quality monitoring	43	6
Public Health Regulations	33	7

Table 15: Summary of the Adaptation Actions for the Health sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Public Health Regulations	To establish and enforce comprehensive public health regulations that effectively protect community health, enhance compliance, and support sustainable practices across various sectors.	□ Effective evaluation of current public health regulations and identification of gaps. □ Provision of resources, training, and personnel for local health authorities. □ Public awareness campaigns to educate residents on the importance of health regulations. □ Collaboration with healthcare providers, local businesses, and community leaders to ensure compliance. □ Implementation of systems for tracking compliance and reporting violations. □ Introduction of positive reinforcement measures (e.g., recognition programs, subsidies). □ Robust legal frameworks to deter violations and allocate sufficient funds for enforcement.	Medium-term	Human Technology Finance	TMA	Ghana Health Service (GHS) Ministry of Health (MoH) Local Health institutions and clinics EPA WHO NGOs Academic and Research Institutions International Development Partners (e.g., UNDP) Traditional authorities Gender Advocacy groups Media	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Construct and improve infrastructure	To construct and improve health-related infrastructure that is accessible, resilient, and adaptable to community needs, enhancing the capacity to deliver essential health services and promoting overall public health resilience.	□ Alignment with community health needs (clean water access, sanitation, emergency health services) □ Financial feasibility for long-term sustainability (affordable construction and maintenance costs) □ Technical compatibility with local capabilities (materials, technology, labor availability) □ Incorporation of climate-resilient and sustainable design principles (environmentally friendly materials, energy-efficient systems) □ Community engagement in planning (traditional knowledge, cultural acceptance, ownership) □ Ongoing maintenance planning (local staff training, durable materials) □ Scalability and replicability of infrastructure models (adaptable to similar health and environmental challenges) □ Monitoring systems for infrastructure performance and health impact (real-time assessment and continuous improvement)	Long-term	Human Technology Finance	MoH	MLGDRD MoH GHS EPA Solar Energy Companies NGOs CBOs International Development Partners Academic and Research Institutions Local communities Health institutions and local clinics	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Public Health Education Campaigns	To design and implement effective public health education campaigns that enhance community health knowledge, promote healthy behaviours, and ensure alignment with local health priorities, ultimately leading to improved public health outcomes.	□ Tailoring education campaigns to address specific health challenges and literacy levels of different community groups. □ Designing campaigns that respect local cultural norms, languages, and traditions. □ Ensuring inclusivity by involving marginalized groups. □ Developing messages grounded in scientific evidence and local health data. □ Engaging community leaders, healthcare providers, schools, and local organizations in the campaign. □ Utilizing diverse communication platforms (radio, social media, community gatherings, print media). □ Establishing systems to assess campaign effectiveness and gather feedback. □ Ensuring public health education is an ongoing initiative for long-term behavioral change.	Short term	Human Technology Finance	TMA	GHS MoH Municipal Health Department Ministry of Education (MoE) EPA Health focused - NGOs International Development Partners Academic and Research Institutions Local communities and Traditional leaders Local radio station and media outlets Women Groups	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Afforestation	To protect public health and health infrastructure from the adverse effects of flooding. This involves growing trees to reduce the risk and impact of flooding on health facilities and communities, ensuring continuous access to healthcare services.	□ Develop afforestation strategies that complement existing agricultural practices, such as agroforestry. □ Ensure flexibility in afforestation approaches to adapt to local conditions and farmer preferences. □ Select tree species that enhance soil health, prevent erosion, and promote biodiversity. □ Prioritize the use of native tree species to enhance ecological balance and resilience. □ Engage local communities in the planning and implementation of afforestation projects. □ Foster collaboration between government, NGOs, and the private sector to support afforestation efforts. □ Explore economic incentives, such as carbon credits or grants, to encourage farmer participation. □ Raise awareness about the benefits of afforestation and provide education on best practices. □ Implement monitoring systems to assess the ecosystem services provided by afforestation.	Short term	Human Technology Finance	TMA	GHS MoH EPA NGOs CBOs Traditional leaders and local authorities International Development Partners Academic and Research Institutions	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		Invest in research to understand the long-term impacts of afforestation on agricultural systems.					
Early warning systems	To integrate sustainable and resilient practices into the health sector. This involves encouraging the efficient use of heat resilient gadgets eg. fans, Air conditions, etc to reduce environmental impact of heat on health and enhance resilience.	□ Integrate data from various sources (meteorological, geological, social) for comprehensive risk assessments and timely alerts. □ Engage local communities in the development and implementation of early warning systems to ensure relevance and accessibility. □ Implement public awareness campaigns to educate residents about early warning systems and emergency procedures. □ Provide training for municipal staff, emergency responders, and community leaders on using and managing early warning systems. □ Invest in necessary infrastructure for effective early warning systems, including communication technologies and monitoring stations. □ Conduct cost-benefit analyses to evaluate the economic viability of early warning initiatives.	Medium term	Human Technology Finance	TMA GMeT	GHS MoH EPA Waste management companies NGOs CBOs International Development Partners Academic and Research Institutions Local communities	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Design early warning systems to be flexible and adaptable to changing urban conditions and emerging risks. □ Ensure early warning mechanisms align with broader municipal strategies for disaster risk reduction, urban planning, and climate resilience. □ Establish monitoring and evaluation frameworks to assess the effectiveness of early warning systems. □ Address the specific vulnerabilities of men and women in disaster contexts by ensuring the system meets all community members' needs.					
Mangrove restoration	To implement a comprehensive mangrove restoration program that enhances public health, supports climate adaptation, and aligns with local community priorities, ensuring ecological integrity and long-term sustainability.	□ Conducting a detailed assessment of health challenges and ecosystem conditions in mangrove areas. □ Utilizing restoration techniques that enhance mangroves' ability to filter water and improve air quality. □ Addressing potential health risks, such as mosquito breeding, in restoration planning.	Mediun	Human Technology Finance	TMA	NADMO Municipal Disaster Management Committee EPA CBOs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Ensuring mangroves provide sustainable resources like medicinal plants and clean water without overexploitation. - Engaging local communities in restoration efforts, contributing local knowledge, and fostering ownership. - Establishing regular monitoring systems for the health of restored mangroves. - Implementing maintenance activities to sustain mangrove ecosystem services that benefit public health. - Ensuring proper waste management systems to prevent pollution and enhance mangrove effectiveness. - Collaborating with healthcare providers, environmental groups, and local authorities to align restoration with health needs. - Providing training and education on the role of mangroves in health through awareness campaigns.				NGOs Local Health Departments Academic and Research Institutions Traditional Leaders and Community Elders Media Organizations International Development Partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium, and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Air quality monitoring	To establish a robust air quality monitoring system that effectively tracks pollution levels, informs the public about air quality impacts on health, and supports policy decisions for improved environmental and public health outcomes.	□ Conducting a comprehensive assessment of existing air quality conditions in Tema. □ Investing in reliable, modern air quality monitoring equipment tailored to local conditions. □ Regular maintenance of monitoring systems for accuracy and longevity. □ Positioning monitoring stations in high-activity areas, industrial zones, and pollution-prone regions. □ Training local personnel in equipment operation, data collection, and analysis. □ Making air quality data publicly available through reports, dashboards, and workshops. □ Partnering with industries, local authorities, and environmental organizations for coordinated efforts. □ Using monitoring data to inform policy decisions and develop targeted air quality improvement strategies. □ Establishing clear links between monitoring efforts and actionable interventions.	Medium	Human Technology Finance	TMA	EPA GHS MoH Municipal Health Department Ministry of Education (MoE) EPA Health focused - NGOs International Development Partners Academic and Research Institutions Local communities and Traditional leaders Local radio station and media outlets Women Groups	

9.5.5 Gender Mainstreaming

The prioritized gender actions focus on delivering economic empowerment to women and other marginalized groups (youth and PWDs). Climate education programs are essential for raising awareness about climate change and equipping communities with skills to adapt. Gender-responsive education ensures that both women and men can actively and equitably participate in climate action, promoting resilience and fostering informed citizens who advocate for sustainable practices. Gender mainstreaming addresses inequalities by incorporating the needs and contributions of all genders into policies and plans. This approach promotes social justice, enhances program effectiveness, and strengthens community resilience for sustainable development. Livelihood diversification builds economic resilience by reducing vulnerability to climate change, market shifts, and external pressures. Supporting diverse income-generating activities creates equitable opportunities, especially for women and marginalized groups, while maximizing community skills and resources.

Providing relief items during emergencies supports immediate recovery and stability. Effective distribution systems that consider the diverse needs of affected populations ensure equitable and impactful assistance, particularly for marginalized groups, fostering recovery and inclusion. Improved fish-smoking infrastructure enhances food security, boosts product quality, and supports local livelihoods. Modernizing processing methods reduces health risks, ensures sustainability, and strengthens economic resilience, particularly for women who play key roles in fish processing. Nature-based solutions (NBS) address challenges like climate change and biodiversity loss by leveraging natural ecosystems. NBS improve resilience, ecosystem health, and economic opportunities. Integrating gender perspectives ensures inclusive, equitable, and effective outcomes. Sustainable livelihood programs reduce poverty and improve well-being by offering diverse, eco-friendly income opportunities. These programs enhance food security, economic resilience, and community empowerment. Including gender perspectives ensures all members benefit equitably, fostering inclusive and sustainable growth.

Table 16: Ranking of adaptation options for the Gender Mainstreaming sector

Gender	Final score	Rank
Climate Educational Programs	48	1
Gender Mainstreaming in Action Plans	48	1
Diversification of Livelihoods	48	1
Provision of relief items	48	1
Improved fish smoking Infrastructure	47	5
Nature-base solution	47	5
Sustainable Livelihood Programs	45	7

Table 17: Summary of the Adaptation Actions for the Gender mainstreaming sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Climate Education programmes	To develop and implement inclusive climate educational programs that enhance awareness and understanding of climate issues, empower individuals to take action, and foster community resilience, particularly focusing on gender perspectives.	- Development of educational content addressing gendered impacts of climate change. - Capacity-building programs focusing on leadership and resilience for women and girls. - Culturally appropriate and accessible materials for diverse gender groups. - Partnership with gender-focused organizations for co-creation and delivery of programs. - Highlighting stories of women and gender-diverse leaders in climate action. - Alignment with existing gender and climate policies for institutional support. - Systems to track inclusivity and impact, ensuring continuous improvement.	Short-term	Human Technology Finance	TMA	Ministry of Gender, Children and Social Protection NGOs Community-based organizations (CBOs) Academic and Research Institutions Women groups and organizations Local educational institutions and schools Traditional leaders International and donor organizations	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Sustainable livelihood programmes	To develop and implement sustainable livelihood programs that enhance community resilience, promote equitable economic opportunities, and integrate gender perspectives to empower all members of the community.	□ Diversification of income sources through alternative livelihoods like eco-tourism, small-scale agro-processing, and local handicrafts. □ Capacity building of local communities through training on new technologies, sustainable farming practices, business skills, and financial literacy. □ Access to credit, microfinance, and grants to support sustainable businesses and improve existing practices. □ Linkage to financial institutions and government funding opportunities to enable resource access for starting or expanding ventures. □ Adoption of climate-resilient practices, such as sustainable agriculture, water conservation, and renewable energy, to ensure long-term viability and reduce environmental degradation.	Short term	Human Technology Finance	TMA	Ministry of Gender, Children and Social Protection CBOs NGOs International Development Agencies (e.g., UNDP) Academic and Research Institutions Local women's organization Micro finance institutions Educational institutions offering entrepreneurship and skills training programs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Inclusivity and gender-sensitive design, ensuring equal access to resources, training, and decision-making for women and marginalized groups. □ Community ownership and participation in the planning and implementation of livelihood programs to foster responsibility and tailor solutions to local needs. □ Regular monitoring and evaluation to ensure the success, adaptability, and long-term impact of the programs.					
Diversification of livelihoods	To promote the diversification of livelihoods in communities, enhancing economic resilience, reducing dependency on single income sources, and empowering individuals, especially marginalized groups.	□ Engagement of diverse community members to identify local skills, resources, and preferences. □ Provision of training programs to equip individuals with necessary skills for new livelihoods. □ Establishment of connections to markets and development of value chains for economic viability. □ Facilitation of access to microfinance, grants, and low-interest loans for livelihood investments.	Short term	Human Technology Finance	TMA	Ministry of Gender, Children and Social Protection CBOs NGOs International Development Agencies (e.g., UNDP)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Promotion of climate-resilient livelihood options like eco-tourism, agroforestry, and renewable energy. - Development of systems to monitor and support the performance of diversified livelihoods. - Support for diversification initiatives through local policies, institutions, and partnerships.				Academic and Research Institutions Training centers and Vocational schools Microfinance institutions	
Improved fish smoking Infrastructure	To enhance fish smoking infrastructure in communities, promoting safer, more efficient, and environmentally sustainable practices that improve product quality and empower local fish processors.	- Designing fish smoking infrastructure that meets the specific needs of fishmongers, especially women, ensuring ease of use, efficiency, and safety. - Incorporating ventilation and filtration systems to reduce harmful smoke exposure and protect respiratory health. - Offering training and skill development programs tailored for women on infrastructure use, maintenance, and benefits. - Facilitating access to markets and value-added products to increase income and economic status for women fishmongers.	Medium-term	Human Technology Finance	TMA MoFA - WIAD	Ministry of Gender, Children and Social Protection NGOs CBOs International Development Agencies (e.g., UNDP) Local women organizations Training centers and Vocational schools	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Providing access to affordable financing, grants, or loans, along with financial literacy programs. □ Designing energy-efficient and environmentally sustainable infrastructure to reduce reliance on wood-burning methods. □ Encouraging the active involvement of women in the decision-making process for infrastructure selection and implementation.					
Gender Mainstreaming in Action Plans	To effectively integrate gender considerations into action plans across various sectors, ensuring equitable outcomes, enhanced participation, and the empowerment of marginalized groups.	□ Active participation of women, men, and gender-diverse individuals in action plan development. □ Training for policymakers on gender sensitivity to address diverse needs. □ Use of gender-disaggregated data to prioritize gender-specific interventions. □ Alignment of gender mainstreaming with climate, development, and gender equality policies.	Medium term	Human Technology Finance	TMA	Ministry of Gender, Children and Social Protection CBOs NGOs International Development Agencies (e.g., UNDP) Academic and Research Institutions	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Dedicated budgets and resources for gender-focused initiatives in action plans. □ Monitoring and evaluation frameworks to assess gender outcomes and ensure accountability. □ Strengthened local capacities through involvement of grassroots organizations and women's groups.				Local women's organization Micro finance institutions Educational institutions offering entrepreneurship and skills training programs WIAD Gender Desk	
Provision of relief items	To ensure the effective and equitable provision of relief items to communities affected by emergencies, enhancing resilience and addressing the specific needs of diverse populations	□ Conducting comprehensive needs assessments to prioritize vulnerable populations. □ Establishment of robust logistics systems for timely and equitable delivery of relief items. □ Involvement of local leaders and stakeholders in planning and communication. □ Ensuring relief items meet quality standards and are sustainable and environmentally friendly. □ Developing partnerships with government agencies, NGOs, and private organizations for resources and funding.	Medium term	Human Technology Finance	TMA		

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Implementing systems to monitor distribution and usage of relief items, ensuring accountability. □ Aligning relief provision with broader adaptation and resilience-building efforts.					
Nature-based solution	To implement and promote nature-based solutions (NBS) that enhance ecosystem resilience, provide sustainable livelihoods, and address social and environmental challenges while integrating gender perspectives.	□ Restoration of mangroves, wetlands, and coastal ecosystems to mitigate flood risks, protect biodiversity, and improve water quality. □ Cost-effective and sustainable NBS alternatives to traditional infrastructure solutions, leveraging natural processes like water filtration and erosion control. □ Active community involvement, particularly local communities and fishers, in planning, implementing, and maintaining NBS projects. □ Enhancement of local biodiversity by restoring habitats that support a wide range of species, crucial for ecological balance and food security.	Medium term	Human Technology Finance	TMA		

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Integration of NBS into broader climate adaptation plans to reduce vulnerability to climate change. - NBS as a complement to other adaptation measures, enhancing overall resilience of communities and ecosystems. - Regular monitoring of NBS effectiveness to ensure goals are met. - Establishment of knowledge-sharing platforms to share best practices and build adaptive management strategies. - Generation of additional social and economic benefits, including job creation in ecosystem restoration, improved agricultural productivity, and sustainable income from eco-tourism or non-timber forest products.					

9.5.6 Water Resources

According to the Tema Metropolitan Assembly Vulnerability Assessment, water resources is considered as one of the at risk sectors due to the urban expansion of Tema Metropolis identified as the most vulnerable sector and requires significant attention. Five of the seven adaptation actions that were identified and assessed through the multicriteria analysis (MCA) are discussed below due to their cross cutting nature of the adaption option and its discussion in previous sectors. These actions target water scarcity for household and risk to water resources for communal use. Access to clean drinking water is essential for health, well-being, and economic productivity. Reliable access reduces waterborne diseases, improves nutrition, supports education by saving time on water collection, and boosts local economies. Addressing water supply challenges through integrated solutions strengthens resilience to climate change and water scarcity.

Enforcing building regulations ensures safe construction practices, protects water resources, and promotes environmental sustainability. Proper enforcement prevents issues like flooding, contamination, and structural failures, fostering sustainable development, public health, and community safety. Community education and engagement are key to sustainable water management. By equipping individuals with knowledge and skills, communities can conserve water, prevent pollution, and use resources responsibly. Active involvement fosters accountability, stronger community bonds, and better environmental outcomes, enhancing resilience to climate change. Communal water storage management optimizes resources, especially in water-scarce areas or during seasonal fluctuations. Shared management ensures equitable access, minimizes waste, and strengthens community collaboration for sustainable water use and conservation. Water quality monitoring safeguards public health, protects ecosystems, and sustains water resources. Regular assessments help identify contamination, guide corrective actions, and ensure compliance with health standards. Effective monitoring supports informed water management and builds community confidence in their water supply.

Table 18: Ranking of adaptation options for Water resources sector

Water resources	Final score	Rank
Increased Access to Potable Water Supply	47	1
Practice Afforestation	43	2
Construct and Improve Infrastructure	43	2
Enforce building regulations	39	4
Community Education and Involvement	39	4
Communal water storage management	34	6
Water quality monitoring	32	7

Table 19: Summary of the Adaptation Actions for Water resources sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Increased access to potable water	To increase access to potable water in Tema by implementing sustainable and resilient water infrastructure that addresses the water scarcity challenges in arid areas like TMA.	□ Cost-effective water treatment and distribution systems with low maintenance costs for long-term sustainability. □ Collaboration with local governance structures and water authorities for smooth implementation and management. □ Selection of durable, low-maintenance, and efficient water supply technologies suited to Tema's arid climate. □ Flexibility and scalability of solutions to accommodate changes in water demand due to population growth or climate shifts. □ Incorporation of culturally appropriate water sources and systems, such as community-owned wells, to improve acceptance. □ Community engagement to raise awareness about water conservation and the health benefits of potable water access. □ Consideration of women and girls' roles in water collection, aiming to reduce their workload and improve safety at access points.	Medium-term	Human Technology Finance	TMA	MSWR EPA NGOs Local communities Educational Institutions Private sector International development agencies and donors Women's advocacy groups and gender-focused organizations. Health and education institutions for awareness campaigns. Research institutions for technology and scalability solutions. Traditional leaders and local influencers	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		Equitable access to water across socio-economic groups, focusing on marginalized areas traditionally lacking adequate services.					
Enforce building regulations	To effectively enforce building regulations that promote sustainable construction practices, enhance water resource management, and ensure community safety and resilience against environmental challenges.	- Strengthened legal frameworks to prevent illegal encroachments, including updated laws on wetlands and waterway protections. - Clear legal consequences for violations to support long-term protection efforts. - Collaboration between local government, environmental agencies, and conservation organizations for effective site management and enforcement. - Regular surveillance and audits of construction activities to monitor compliance. - Public awareness campaigns on the ecological importance of the Sakumo Ramsar Site and the consequences of illegal construction. - Continuous monitoring and surveillance of protected lands using tools like satellite imagery and drones.	Medium term	Human Technology Finance	TMA EPA	MLGRD MESTI EPA Water Resources Commission Ghana Police Service NGOs CBOs Private Sector Unit committees Traditional authorities Media International development and donor organization	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Community involvement in monitoring efforts and decision-making processes to enhance enforcement effectiveness. - Capacity building for enforcement officers, urban planners, and environmental regulators through targeted training programs. - Incentives for developers and property owners who comply with building regulations, such as tax breaks or recognition for environmentally friendly projects.				Academic and research organizations	
Water quality monitoring	To implement comprehensive water quality monitoring systems that ensure safe and sustainable water resources, enhance public health, and support effective water management practices.	- Regular water quality testing at various points in the distribution network, including wells, boreholes, and treatment facilities. - Testing of key water quality parameters, such as pH, turbidity, heavy metals, microbial contamination, and pollutants. - Community engagement in water quality monitoring, including training community members to conduct basic tests. - Public awareness campaigns to educate residents on the importance of water quality monitoring and reporting contamination. - Accurate data collection, analysis, and trend monitoring to identify potential risks and inform water management decisions.	Short term	Human Technology Finance	TMA	Ghana Water Company Limited (GWCL) Community Water and Sanitation Agency (CWSA) EPA Ministry of Sanitation and Water Resources NGOs Local communities Private sector Traditional leaders CBOs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Collaboration with research institutions or local universities for enhanced data quality and analysis. □ Close collaboration between local government, health authorities, environmental groups, and research institutions for effective monitoring. □ Integration of modern technology, such as smart sensors, remote sensing, and GIS, for real-time water quality monitoring and pollution tracking. □ Strong regulatory framework and enforcement of water quality standards through regular inspections, audits, and penalties. □ Training of local authorities and water management agencies in water quality monitoring techniques and data analysis. □ Transparency in water quality monitoring by sharing regular reports with the community and relevant stakeholders. □ Public access to water quality data to inform the community about the safety of water sources.					

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ An emergency response plan for addressing contamination events and training local authorities and community members on water safety protocols. □ Adequate funding and long-term budgeting for water quality monitoring systems, including technology use and capacity-building. □ Collaboration with international organizations or donor agencies for additional funding sources.					
Community Education and involvement	To enhance sustainable water management practices and improve community resilience by promoting education and community involvement on water conservation, investment in water-saving technologies, and community-led water resource initiatives in Tema .	□ Community education on the importance of preserving water resources and wetlands, emphasizing environmental consequences of encroachment. □ Involvement of local communities in decision-making processes through public consultations and workshops. □ Training on sustainable practices, including eco-friendly construction, water management, and land use. □ Community participation in monitoring activities, acting as “watchdogs” to report unauthorized construction and protect natural resources. □ Building trust and transparency through regular communication between local authorities, environmental agencies, and the community.	Short term	Human Technology Finance	TMA	Ministry of Sanitation and Water Resources (MSWR) EPA Zoomlion Ghana Limited NGOs Local communities Private sector Local schools CBOs	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
	Fostering a sense of ownership, responsibility, and active participation in sustainable practices	□ Incentivization and organization of local stewardship programs, such as clean-up drives and habitat restoration. □ Emphasis on the relationship between climate change, environmental protection, and community resilience to foster support for conservation. □ Increased community involvement in protecting the Sakumo Ramsar Site and surrounding water resources through active participation in conservation efforts.				Women's groups and associations Municipal water authorities	
Construct and Improve Infrastructure	To construct and enhance dam infrastructure in Tema to support irrigation, improve water availability, and enhance agricultural productivity in response to arid climate conditions. This will help stabilize water supplies for farming, contributing to food security, improved livelihoods, and climate resilience.	□ Integrate efficient irrigation systems, such as drip irrigation, to minimize water wastage and optimize water distribution. □ Implement soil conservation practices to protect soil health and ecosystems affected by dam construction. □ Respect local customs and traditional values related to water use to foster acceptance and support. □ Establish financial models for regular dam maintenance, repairs, and upgrades to ensure functionality of water infrastructure. □ Provide training for farmers on efficient irrigation practices and water management for agricultural benefits.	Long term	Human Technology Finance	MSWR	TMA MSWR EPA GWCL Ghana Irrigation Development Authority MoFA WRC NGOs Local communities Private Sector	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Develop and raise awareness about early warning systems for flooding or drought, and response strategies. □ Ensure equitable access to irrigation water for marginalized farmers and communities to prevent conflicts.				CBOs Traditional leaders Farmer cooperatives	
Practice Afforestation	To promote afforestation practices that enhance water retention and soil stability in Tema, contributing to sustainable water management and increased resilience to water scarcity.	□ Selecting tree species compatible with local soil types for optimal water absorption and root stability. □ Establishing community-led initiatives for tree care to enhance survival rates and water benefits. □ Providing incentives, such as access to timber or non-timber forest products, to encourage community participation in afforestation. □ Raising local awareness about the ecological and hydrological benefits of afforestation to gain community support.	Short-term	Human Technology Finance	TMA	MSWR EPA WRC Forestry commission NGOs Local communities Private Sector Farmer groups	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Communal water storage management	To establish effective communal water storage management systems that enhance water availability, promote sustainable use, and foster community collaboration and resilience against climate variability.	□ Active community involvement in planning, construction, and maintenance of water storage facilities. □ Community ownership of water storage facilities to ensure sustainability and responsibility. □ Equitable water distribution systems that serve all community members, especially vulnerable groups. □ Clear guidelines for prioritizing access during dry spells or droughts to protect vulnerable populations. □ Integration of communal water storage systems with local water resources, such as rainwater harvesting and boreholes. □ Flexible systems that accommodate fluctuations in water availability throughout the year. □ Training for local community members on the maintenance, operation, and monitoring of water storage systems. □ Capacity building on the long-term benefits of proper water storage, including health, hygiene, and agricultural resilience.	Medium term	Human Technology Finance	TMA		

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium or Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Training of local leaders to support the maintenance and functionality of water storage systems. □ Collaboration with local authorities and NGOs for technical support, regulatory oversight, and resources. □ Development of a clear maintenance plan, including inspections, repairs, and replenishment of materials. □ Adequate funding through community water funds or local government support for long-term maintenance.					

9.5.7 Fisheries Sector

According to the Tema Metropolitan Assembly Vulnerability Assessment, fisheries is as one vibrant economic activities in Tema. The sector employs a significant proportion of the active population including a majority of migrant youth as fishermen and women as fishmongers. However, the sector faces significant risks and vulnerability. The participatory stakeholders identified four key adaptation option, which are discussed below. Enforcing urban planning and land use bye-laws is essential for sustaining the fisheries industry while protecting coastal and marine ecosystems. These laws promote organized development around fishing communities, reducing vulnerability to climate change and other risks. Proper implementation ensures stable livelihoods, improved public health, and sustainable development for local fisheries. Educational programs are vital for empowering fishers, stakeholders, and communities with knowledge and skills for sustainable fisheries management. By teaching ecological principles, fishing regulations, and conservation strategies, these programs protect aquatic ecosystems and promote best practices that balance economic needs with environmental sustainability.

The fisheries sector in Tema is highly vulnerable to climate change impacts, including coastal erosion, flooding, and rising sea levels, which threaten livelihoods and infrastructure. Indigenous construction techniques, adapted to local environmental and cultural conditions, offer a climate-resilient solution. By combining these methods with modern materials and knowledge, communities can access safe, durable, and affordable housing. This approach preserves cultural heritage, empowers local expertise, and fosters acceptance and ownership of climate adaptation measures, ensuring long-term success. Climate-related hazards such as high tides, storms, and unpredictable sea conditions pose significant risks to Tema's fisheries sector, damaging boats, equipment, and threatening lives. Developing an early warning system to alert fishers of extreme high tides can help mitigate these risks. These systems enhance disaster preparedness, reduce economic losses, and strengthen the community's resilience. By integrating modern technology with traditional knowledge, warnings can be made both accessible and actionable, ensuring the safety and stability of the fisheries sector, a key economic pillar of the community.

Table 20: Ranking of adaptation options for Fisheries Sector

Fisheries	Final score	Rank
Enforcement of urban planning and land use bye-laws	48	1
Educational Programs	48	1
Using indigenous technology to bolster and reinforce resilient housing structure	48	1
Early Warning and Response Mechanisms	46	4

Table 21: Summary of the Adaptation Actions for Fisheries Sector

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Enforcement of urban planning and land use bye-laws	The overall objective of enforcing urban planning and land use bye-laws in the fisheries sector in Tema is to protect and regulate the sustainable use of land and water resources critical to the livelihoods of those in the fisheries sector.	□ Clear, accessible, and tailored urban planning and land use bye-laws specific to the fisheries sector. □ Education and outreach programs to ensure local fishing communities understand the regulations and their benefits. □ Adequate resources and trained personnel for the enforcement of urban planning and land use laws. □ Deployment of monitoring systems, establishment of enforcement agencies, and sufficient budget for inspections and penalties. □ Strong institutional support and political will to back enforcement efforts. □ Sustainable urban development planning that minimizes environmental impacts, particularly within fisheries operational zones.	Medium-term	Human Technology Finance	TMA	Ministry of fisheries EPA Urban Planning and Development Partners CBOs NGOs Academic and Research Institutions Community leaders and traditional authorities Private sector partners (e.g., companies in water infrastructure and eco-tourism)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		- Regulations that prevent encroachment on critical fishing areas and protect water quality and habitats. - Regulations focused on minimizing pollution, controlling waste disposal, and preventing habitat destruction. - Mechanisms for conflict resolution, such as mediation and dispute processes, to address land use conflicts between stakeholders.					
Educational Programs	To develop and implement educational programs that enhance knowledge and skills related to sustainable fisheries management, fostering community engagement and promoting responsible practices among stakeholders	- Thorough needs assessment to understand knowledge gaps within the fisheries sector. - Tailored educational programs addressing the unique challenges faced by fishermen, fishmongers, and community members. - Engagement of local experts, community leaders, and stakeholders in the development and delivery of educational programs.	Short-term	Human Technology Finance	TMA	Ministry of Fisheries EPA CBOs NGOs Academic and Research Institutions Private Sector	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Adequately trained facilitators equipped with the necessary knowledge and skills to engage the target audience. □ Use of diverse teaching methods, such as community workshops, radio programs, visual aids, and hands-on demonstrations. □ Ongoing educational programs with follow-up mechanisms like refresher courses, community forums, or online platforms for continuous learning. □ Alignment of educational content with existing policies, regulatory frameworks, and best practices in the fisheries sector. □ Monitoring and evaluation of educational programs with clear objectives, indicators, and participant feedback to assess effectiveness. □ Securing sustainable funding and resources through partnerships with government, NGOs, and private sector actors.				Professional Training Organizations International Development Partners Local media outlets (e.g., radio, social media) Traditional leadership structures	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Early Warning and Response Mechanisms	The general objective of implementing Early Warning and Response Mechanisms (EWRM) in the fisheries sector is to enhance the resilience of fishermen and other coastal communities by providing timely, accurate, and actionable information on extreme weather events such as high tides, storms, and rough seas. This will allow fishers to take precautionary actions, reduce risks, and safeguard their lives and livelihoods. Participants noted of the piloting of an early warning mobile application, which forewarns fishermen of extreme high times storms, and unpredictable sea conditions.	□ Accessibility of the early warning system through mobile applications, text messages, radio broadcasts, or community-based communication methods. □ Timely warnings provided well in advance of extreme weather events to give fishermen sufficient time for precautions. □ Reliance on reliable data sources such as accurate weather forecasts and tide predictions for correct alerts. □ Education and training for fishermen on how to use and interpret early warning alerts. □ Integration of the early warning system with local knowledge and traditional fishing practices to enhance effectiveness. □ Collaboration between local government, weather agencies, NGOs, and community leaders to ensure a well-coordinated and comprehensive system.	Medium-term	Human Technology Finance	TMA NADMO GMeT	EPA Forestry Commission Ministry of fisheries CBOs NGOs CSOs Academic and Research Institutions International Disaster Response Agencies Local Educational Institutions and Training Providers Private Sector Partners (e.g., technology and equipment suppliers)	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Building trust among fishermen in the reliability and usefulness of the early warning system. □ Availability of alternative communication channels (e.g., radio, public announcements, or community networks) in case of technical failures. □ Continuous monitoring and regular evaluations of the early warning system, with feedback from the community to refine and improve its effectiveness.				United Nations Agencies (e.g., UNDP, UNICEF) Local community groups and leaders	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
Using indigenous technology to bolster and reinforce resilient housing structure	To promote the use of indigenous technology in constructing and reinforcing resilient housing structures that support fisheries communities, enhancing their ability to withstand environmental challenges. This approach aims to reduce vulnerability to climate-related risks such as flooding, storms, and extreme weather conditions, while ensuring that housing solutions are sustainable, cost-effective, and culturally appropriate	□ Adequate training for local builders, artisans, and the community on utilizing and reinforcing indigenous technologies. □ Capacity building programs focused on preserving indigenous knowledge and introducing modern tools for improved construction. □ Integration of indigenous technologies with modern building standards and regulations to ensure safety and durability. □ Evaluation of indigenous technologies for compatibility with current climate change challenges (e.g., rising temperatures, changing rainfall patterns, and increasing storm intensity). □ Availability and accessibility of materials required for indigenous construction technologies, such as bamboo or mud.	Medium-term	Human Technology Finance	TMA NADMO	MLGRD MESTI EPA NADMO CBOs NGOs Academic and Research Institutions Private Sector International Development Partners	

ADAPTATION ACTIONS	OBJECTIVES	INDICATORS OF SUCCESS	TIME FRAME (Short, Medium and Long Term)	RESOURCES (Finance, Human, Technology)	IMPLEMENTING PARTNERS		Estimated costs
					Lead	Collaborating	
		□ Promotion of sustainability by using renewable resources and minimizing environmental impact in construction practices. □ Collaboration with external experts (engineers, architects, environmental specialists) to enhance and modernize traditional techniques. □ Partnerships with academic institutions, NGOs, and government agencies to provide technical support and reinforce indigenous technologies.					



10

Framework for Adaptation Monitoring, Evaluation, and Learning

Monitoring, Evaluation, and Learning (MEL) plays a crucial role in adaptation planning by enabling the tracking of progress, assessing impacts, and ensuring the efficient use of resources. In Tema, MEL would offer transparency to stakeholders and promote an adaptive management approach, allowing for adjustments to projects based on real-time data. By capturing both successes and challenges, MEL fosters a culture of continuous learning that encourages knowledge sharing and informs future initiatives. Furthermore, insights from MEL can help local policymakers refine existing policies, identify best practices for scaling, and ultimately enhance the effectiveness and sustainability of adaptation efforts in the region.

10.1 Building on Existing Structures to Facilitate Mainstreaming

Monitoring, Evaluation, and Learning (MEL) is essential for tracking progress in climate adaptation and assessing advancements toward climate resilience. This system is designed to complement and strengthen both national and metropolitan monitoring and evaluation efforts, creating a comprehensive framework for measuring outcomes and effectiveness. By aligning with existing structures, MEL not only tracks adaptation progress but also promotes learning about climate change, ensuring a unified approach to development goals and contributing to a sustainable agenda.

In Ghana, a range of laws, policies, and plans provide a foundation for developing monitoring and evaluation systems for development initiatives. The National Development Planning Commission (NDPC) holds the primary responsibility for M&E, establishing a framework that analyses the interconnections between inputs, activities, outputs, outcomes, and impacts in delivering public services. Key legislative documents, including Articles 86 and 87 of the 1992 Constitution, the National Development Planning System Act of 1994 (Act 480), and the National Development Planning (System) Regulations of 2016 (LI. 2232), mandate government agencies to implement M&E for their policies and programs.

For the Tema Metropolitan Assembly (TMA), there is an expectation to develop its own M&E plan that includes sub-district levels, guided by the NDPC's frameworks (NDPC, 2020). While there is no dedicated M&E plan for climate change adaptation, the NDPC guidelines cover indicators related to climate change, the Sustainable Development Goals (SDGs), Agenda 2063, and green economy initiatives. The integration of climate change into the TMA's Medium Term Development Plan (MTDP) emphasizes the importance of monitoring and evaluating relevant indicators and targets. However, the NDPC's M&E framework does not explicitly focus on the learning aspect, which is crucial for continuous improvement. Globally, the learning component of MEL is an emerging concept that requires intentional efforts to enhance its application within the context of climate adaptation.

10.2 MEL Design

The framework for the Tema Metropolitan Assembly (TMA) adaptation Monitoring, Evaluation, and Learning (MEL) system is designed to achieve the following objectives:

- Track the implementation of agreed adaptation measures within the Metropolitan to ensure they are carried out effectively.
- Evaluate the success of adaptation actions in reducing vulnerability within the community.
- Generate valuable insights and knowledge that inform policy development, decision-making, and raise awareness among stakeholders.
- Provide information for both local and national reporting, ensuring transparency and accountability.
- Develop a system for collecting and storing climate data to monitor and assess adaptation progress at the local level.
- Set up clear communication channels to share information about the adaptation strategy and efforts within the Metropolitan.

Operationalizing the adaptation MEL system requires integrating climate adaptation considerations and MEL planning into the Metropolitan development plans and policies, such as the Annual Action Plans (AAP) and the district's Medium Term Development Plan (MTDP).

Table 22: Outline of approach to MEL of TMA adaptation actions

Steps	Indicative Activities—To Be Led by the TMA Planning Coordination Unit
1. Monitoring the Adaptation Actions	• Identify adaptation activities for monitoring using both qualitative and quantitative performance measures to assess progress toward the adaptation objectives. • Define metrics and indicators to document progress for the selected adaptation activities. • Collect data on the defined metrics and indicators throughout the adaptation implementation process.
2. Reviewing the Adaptation Process to Assess Progress, Effectiveness, and Gaps – Evaluation	• Establish methods for measuring and communicating effectiveness levels and identifying gaps in the adaptation process. • Integrate insights from recent studies, new scientific developments, and feedback from ongoing adaptation efforts to evaluate and improve strategies. • Revise adaptation activities based on evaluation results and metrics.
3. Iteratively Updating the Adaptation Plan – Learning	• Update adaptation activities in response to the information gathered during monitoring and evaluation. • Document key lessons learned, highlighting successful strategies and areas for improvement. • Establish criteria for success and/or failure of adaptation initiatives. • Implement necessary remedial measures based on evaluations. • Align learning outcomes and corrective actions with broader targets outlined in the TMA Medium Term Development Plan (MTDP).

4. Communication – Reporting Progress, Process Effectiveness, Outreach, and Knowledge Dissemination	• Disseminate adaptation-related documents and learning outcomes to stakeholders. • Include information in the TMA annual progress report regarding the advancement and effectiveness of adaptation actions.
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Source: Adapted (and modified) from the Government of Liberia's four-step approach to the MEL of its NAP. See Environmental Protection Agency, Republic of Liberia, 2022.



11



Conclusion and Recommendations

11.1 Conclusion

The Adaptation Action Plan for the Tema Metropolitan Assembly marks a significant milestone in subnational climate change adaptation in Ghana. As a pioneering initiative, the Plan positions TMA as a leader in localized adaptation efforts, leveraging Ghana's National Adaptation Plan (NAP) framework. By integrating science-based approaches, participatory governance, and innovative financing, it addresses immediate vulnerabilities while building long-term resilience and aligning with the Sustainable Development Goals (SDGs) and the Medium-Term Development Plan (MTDP). Its emphasis on marginalized groups, including women, youth, and persons with disabilities, ensures that adaptation strategies are inclusive and equitable, setting a transformative example for other districts.

Developed through extensive stakeholder engagement, the Plan involved input from local governments, community leaders, civil society, the private sector, and international partners. Using a multi-criteria analysis (MCA) to rank and prioritize actions, the process ensured evidence-based, transparent, and inclusive decision-making. This collaborative approach not only enhances the plan's relevance and impact but also positions it as a model for effective climate adaptation in Ghana.

This process outlined 52 prioritized adaptation actions across all relevant socioeconomic sectors of TMA. This include agriculture, biodiversity, water resources, disaster risk reduction (DRR) and transportation, health and sanitation sector as well as gender. The plan's sector-specific adaptation actions provide innovative solutions tailored to the Metropolis's unique challenges.

The adaptation plan for Tema Metropolitan Assembly (TMA) highlights the urgent need for localized strategies to address the district's specific climate vulnerabilities and enhance its resilience across multiple sectors. With agriculture, urban planning, disaster risk reduction, health, and water resources identified as critical areas, the plan underscores the importance of leveraging tailored solutions to mitigate the impacts of climate change. By integrating community engagement, sustainable practices, and advanced technologies, TMA aims to foster a climate-resilient future that prioritizes the well-being of its residents and ecosystems.

Key actions such as improving drainage systems, promoting climate-resilient agriculture, and implementing early warning systems are essential to reducing exposure to climate hazards like flooding, drought, and extreme weather. The plan also emphasizes the inclusion of vulnerable groups, including women, youth, and persons with disabilities, in adaptation efforts, ensuring equitable access to resources and decision-making processes. With partnerships between government agencies, private stakeholders, and local communities, TMA is positioned to implement these strategies effectively. However, the success of the adaptation plan will depend on sustained financial investment, capacity-building initiatives, and continuous monitoring and evaluation to ensure long-term adaptability and resilience..

11.1.1 Future Outlook

The Tema Metropolitan Assembly is poised to become a model for subnational climate adaptation in Ghana. By leveraging the insights and methodologies developed through this plan, the assembly can not only enhance local resilience but also contribute to national climate adaptation goals.

The plan's emphasis on participatory governance, gender responsiveness, and nature-based solutions positions it as a forward-looking strategy that integrates climate adaptation with sustainable development. Key actions, such as climate-smart agriculture, water conservation, and disaster preparedness, will have far-reaching benefits, including:

- Improved livelihoods for smallholder farmers and vulnerable groups.
- Enhanced biodiversity and ecosystem services.
- Strengthened disaster resilience and reduced economic losses.

11.2 Recommendations

To ensure the success and sustainability of the Adaptation Action Plan, the following actions are recommended:

1. Strengthen Implementation Frameworks

- Establish a dedicated task force or implementation unit within the TMA to coordinate, monitor, and evaluate the adaptation actions outlined in the plan.
- Develop clear timelines and accountability mechanisms to ensure efficient execution of prioritized actions.
- Use participatory tools to involve communities in assessing the effectiveness of adaptation actions

2. Enhance Financial Resourcing

- Explore diverse funding sources such as public-private partnerships, climate finance mechanisms, and international development grants.
- Allocate specific budget lines in the TMA's annual financial plan to support ongoing and emerging adaptation projects.

3. Prioritize Marginalized Groups

- Develop tailored programs that address the specific vulnerabilities of women, youth, and persons with disabilities (PwDs).
- Provide targeted training, financial assistance, and livelihood diversification opportunities for these groups.

4. Invest in Capacity Building

- Organize regular training sessions for local government officials, community leaders, and civil society actors to enhance knowledge and skills in climate adaptation and resilience-building.
- Facilitate knowledge-sharing forums to exchange lessons and best practices with other districts and stakeholders.

5. Strengthen Early Warning Systems

- Improve the accuracy and accessibility of weather forecasting and disaster preparedness alerts to communities, particularly those in high-risk areas.
- Integrate local knowledge into early warning systems to ensure relevance and community ownership.

6. Promote Ecosystem-Based Adaptation

- Prioritize nature-based solutions, such as mangrove restoration, urban greening, and sustainable land-use practices, to enhance ecosystem resilience while mitigating climate risks.

7. Enhance Education, Awareness and Communication on Climate Issues

- Conduct continuous community education campaigns to raise awareness about climate risks and the benefits of adaptation strategies.
- Develop localized communication strategies that resonate with diverse groups, including marginalized populations.

11.2.1 Call to Action

For successful implementation, all stakeholders must play their roles:

- The government must allocate sufficient resources and create enabling policies.
- Communities must embrace ownership of adaptation actions and actively participate in their execution.
- Development partners and the private sector must support through funding, technology transfer, and capacity building.

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Appendix

A. Implementation Roles and Responsibilities.

Climate change is no longer solely an environmental issue; it is a multifaceted challenge that requires cross-sectoral coordination and shared responsibilities. Isolated and uncoordinated efforts within and across sectors can lead to overlapping initiatives and, in some cases, maladaptation. To improve efficiency through cross-sectoral synergies, a diverse range of institutional stakeholder arrangements is essential for the Tema Metropolitan Assembly..

Table 23: Relevant stakeholders, their key roles, responsibilities, and expected outcomes from their engagement in the implementation of the NAP

Institution	Role/Responsibility	Expected Outcome from Engagement
Public Sector		
Metropolitan Planning Coordinating Unit, TMA	- Facilitates the development of climate action plans in TMA.	- Effective integration of climate adaptation in local planning.
	- Leads monitoring and evaluation of climate initiatives.	- Enhanced capacity for monitoring climate actions.
	- Coordinates climate adaptation projects in TMA.	- Increased financing and partnerships for adaptation.
Assembly Members, Town/Area Councils and Unit Committees	- Advocate and facilitate public participation in adaptation initiatives. - Be a liaison between the Metropolitan Assembly and local population in developing and implementing localized climate adaptation plans.	- Enhanced local awareness and support for climate adaptation. - Improved climate implementation of community adaptation initiatives.
TMA Public Departments and Agencies (Agriculture, Disaster Prevention, Health, Natural Resources; National Disaster Management Organisation (NADMO)	- Implements adaptation priorities within their sectors. - Promotes disaster risk reduction and climate risk management. - Mobilizes community involvement for disaster prevention. - Provides relief in times of disaster. - Provides early warning system education and implementation	- Reduced climate vulnerability within sectors and communities. - Strengthened local resilience through sectoral adaptation initiatives. - Lowered community vulnerability to climate and disaster impacts. - Disaster resilience included in adaptation plans.

Institution	Role/Responsibility	Expected Outcome from Engagement
Gender Department	- Ensures climate strategies consider women, youth, and vulnerable groups.	- Increased focus on addressing gender-based climate vulnerabilities.
Ghana Health Service	- Integrates climate change considerations into health risk management at the Metropolitan level.	- Strengthened adaptation for climate-sensitive health risks.
Forestry Commission	- Regulates forest and wildlife resources; provides technical assistance for adaptation measures.	- Technical expertise to support forest and wildlife-related adaptation activities.
National Development Planning Commission (NDPC)	- Develops national policy frameworks, coordinating implementation across districts and Metropolitan ities.	- Comprehensive climate change integration in TMA development plans.
	- Integrates climate adaptation in economic, social, and environmental planning.	- Aligned and coordinated adaptation planning across Metropolitan.
Ghana Meteorological Agency (GMet)	- Supplies climate and weather data for decision-making at the Metropolitan level.	- Access to accurate, Metropolitan-specific climate data.
Environmental Protection Agency (EPA)	- Leads on the NAP process, overseeing pollution control, sanitation, and environmental protection.	- Clear adaptation priorities for TMA sectors.
	- Develops sector-specific vulnerability reports.	- Support for vulnerability assessments.
Ministry of Food and Agriculture (MoFA)	- Oversees agricultural policies in TMA.	- Improved climate resilience in agriculture.
	- Trains extension staff to integrate climate considerations into agricultural practices.	- Effective climate messaging by extension staff.
	- Facilitates technology transfer.	- Improve adaptation of climate smart agriculture
National Commission on Civic Education (NCCE)	- Educates the public on climate change and adaptation measures.	- Increased community understanding and engagement in climate resilience efforts.
Regional Coordinating Council	- Oversees TMA's Climate Change Adaptation Strategy through monitoring and evaluation.	- Enhanced support for smooth implementation of adaptation initiatives.
	- Coordinates regional planning.	
Ministry of Finance	- Manages financing for climate vulnerability assessments and adaptation strategies.	- Financial support for vulnerability assessments and adaptation implementation.
Research and Academia		
CSIR (STEPRI, FRI, CRI, CRI, etc.) UG, Central University College, etc	- Provides technical support, climate education, and capacity building.	- Enhanced climate education and informed adaptation strategies.
	- Conducts climate resilience research relevant to TMA.	
Private Sector		
Farm Input Dealers	- Promote climate-resilient farm inputs and technologies.	- Improved access to climate-adaptive farming technologies.

Institution	Role/Responsibility	Expected Outcome from Engagement
Financial Institutions	- Provide credit facilities for climate-related initiatives.	- Increased financial support for climate adaptation among farmers and businesses.
Farmer-Based Organizations	- Advocate for farmers, enhance bargaining power, and influence policy on adaptation.	- Improved resilience and adaptive capacity among farmers.
Development Partners		
Green Climate Fund, Bilateral Organizations (e.g., GIZ, USAID)	- Mobilize resources, offer capacity development, and facilitate technology transfer for adaptation.	- Financial and technical support for TMA's adaptation projects.
Foreign Embassies (Danish Embassy,	- Mobilize resources, offer capacity development, and facilitate technology transfer for adaptation.	- Financial and technical support for TMA's adaptation projects. Improved capacity building, effective planning, and implementation of adaptation actions
UN Agencies (UNDP, UNICEF, NAP Global Network)	- Provide support for planning, advocacy, research, and monitoring of climate adaptation.	- Improved capacity building, effective planning, and implementation of adaptation actions.
NGOs/Civil Society Organizations		
Abibinsroma Foundation, etc	- Engage in planning, advocacy, education, research, and monitoring of adaptation programs.	- Enhanced community awareness and resilience through supported adaptation projects.
	- Initiate and fund local adaptation efforts.	
Traditional Councils	- Mobilize communities, support engagement for adaptation activities.	- Strong community involvement in climate adaptation practices.
Faith-Based Organizations	- Mobilize communities and raise awareness on climate issues.	- Strong community commitment to climate adaptation practices.
Opinion Leaders	- Champion climate awareness and engage communities.	- Increased local engagement in climate resilience efforts.
Local Media (Tema FM, community information centres, other local radio and television stations, etc)	- Educate and inform the public on TMA's climate adaptation plan and strategies.	- Greater community awareness and support for climate adaptation.
Vulnerable Groups		
Women, Youth, and PWDs	- Participate in the design and execution of adaptation initiatives.	- Greater visibility of climate impacts on vulnerable groups.
	- Engage in public awareness on climate impacts and adaptation.	- Increased advocacy and support for these groups in adaptation measures.

Source: Adapted from Tema Vulnerability Assessment Report.

B. Long List of Adaptation Measures For The Tema Metropolitan Assembly

SECTORS	IDENTIFIED CLIMATE RISKS	PROPOSED ADAPTATION ACTIONS	ASSESSMENT OF IMPACTS OF PROPOSED ACTIONS	SUPPORTING POLICIES
Agriculture	Floods can contaminate water sources and destroy crops, affecting food security and exacerbating poverty	In agriculture, strategies include tree planting alongside promoting climate-smart agricultural practices are being promoted by the Assembly.	The proposed actions such as tree planting and the promotion of climate-smart agricultural practices aim to enhance agricultural resilience and foster sustainable production by improving soil health, water retention, and crop yield while reducing vulnerability to extreme weather events.	National Climate Change Policy Planting for Food and Jobs (PFJ) Program Ghana Agriculture Sector Investment Plan (GASIP)
	For rain dependent farmers in Tema, the unpredictability of weather events makes it challenging to adhere to traditional planting calendars.	Improved weather forecasting through the radio and from social media (whatsapp)	To provide rain-dependent farmers in Tema with improved weather forecasting to reduce the impacts of unpredictable weather events, thereby enhancing their ability to maintain agricultural productivity	
	Extreme maximum temperatures amplify the demand for water by vegetation and accelerates soil moisture evaporation	Improve farm irrigation by creating indigenous water wells on farms	to enhance agricultural resilience by providing reliable access to water during the dry season	
	hotter temperatures create favourable environments for the spread of pests and diseases			
	Flood often contribute to soil degradation and erosion of farm lands.			

Cities and Urban Land Use	Due to Tema Metropolis being the largest industrial area in Ghana, industrial processes significantly contribute to the pollution of the air quality.	Moreover, air quality concerns are being tackled through measures such as reducing fossil fuel usage and enforcing relevant bye-laws	Enforcing relevant bye-laws, are expected to decrease air pollutant emissions, thus improving air quality, reducing respiratory health issues, and promoting a healthier environment for residents.	National Climate Change Policy
	coastal erosion can cause widespread destruction to infrastructure and homes along the beach, leading to displacement and economic hardships	The group noted that coastal erosion is addressed through the construction of sea defence walls	The construction of sea defence walls in Tema is expected to effectively slow coastal erosion by providing physical barriers against wave action, thereby protecting coastal areas, infrastructure, and communities from erosion-induced damage and preserving the ecological integrity of coastal habitats.	Ghana National Spatial Development Framework (NSDF)
	Damage to roads caused by heavy roads often threaten the safety of residents who use the Tema motorway.	Flood risk is being reduced by clearing blocked gutters and sewage systems, alongside improved waste disposal practices	The proposed clearing blocked gutters and improving waste disposal practices, are expected to decrease the likelihood of flooding by improving drainage efficiency and reducing the accumulation of debris (sand) in drains	Medium Term Development Plan
	Climate induced migrants often settle in informal settlements with limited access to basic amenities, including clean water.	Improve employment and accommodation options for migrants and the vulnerable in the municipality	Provision of livelihood and employment options in Tema to reduce the vulnerability of migrants and other minority groups in Tema against climate impacts such as flooding and climate induced impacts	Tema Metropolitan Assembly Annual Action Plan
	City expansion significantly impacts urban agriculture. For instance, some farmers by the Tema Motorway lost their farm lands to the expansion of the motorway roads			Local Government Act, 2016 (Act 936)

Disaster Risk Reduction	Heavy rainfalls often lead to the flooding the metropolis' lagoons and Ramsar sites which have been encroached.	The community members often relocate to family members and friends who have not been impacted by the floods or something generate makeshift blocks to prevent the floods from their residences.	Incorporating flood-resilient urban planning measures can help minimize the impact of flooding on water resources	National Climate Change Policy Ghana National Spatial Development Framework (NSDF)
	Also, the enlargement of the city has led to the increase the slum areas and often informal settlements. These areas face increased vulnerability to fire outbreaks during the dry season due to factors such as poor electrical wiring, combined with the ease of spreading fire in the dry season and limited access to firefighting resources	As well, sensitization campaigns by the fire service and NADMO help combat wildfire/bushfires	Implementing public education campaigns and organizing drills can empower residents to respond effectively and minimize potential damage	Medium Term Development Plan Tema Metropolitan Assembly Annual Action Plan
	The elevated sea levels intensify the vulnerability of coastal areas, predisposing Tema to higher risks of flooding, particularly during storm surges and extreme weather events.	Adaptation strategies in fisheries often involve providing early warning systems and education on tidal waves	The implementation of early warning systems and education initiatives on tidal waves in Tema's fisheries aims to potentially save lives of fishermen by preventing reducing the risk of fatalities during fishing	
	Extreme flood events lead to the destruction of housing structure	using indigenous technology to bolster and reinforce their housing		
		public education efforts have better enhanced community preparedness		

Health	They added that the pollution of the air quality exacerbated by climate elements such as long humid and dry months during harmattan, that this often causes an increase in respiratory diseases, skin disorders, and the inhalation of exhaust fumes by traders leads to complex health issues.	Preventing the boundary of the market being by the road side Conducting public awareness campaigns to educate residents and traders about the health risks associated with poor air quality and the importance of protecting their respiratory health	By relocating markets away from roadside, the potential risks associated with pollution sources such as vehicular emissions decreases, leading to improved respiratory health outcomes for both traders and nearby residents	Mental Health Act, 2012 Ghana Health Policy Tema Metropolitan Assembly Annual Action Plan
	The stressors associated with climate-related disasters, coupled with the anticipation of future impacts, may exacerbate anxiety, depression, and post-traumatic stress disorders within affected communities	Implementing educational programs within communities can raise awareness about the psychological impacts of climate-related disasters and provide coping strategies to manage stress, anxiety, and depression.		National Gender Policy
Biodiversity	They further noted that the encroachment of wetlands further leads to biodiversity loss and flooding through the building in waterways.	According to the group the Assembly is making efforts to address wetlands encroachment through proper issuance of permits and strict enforcement of bye-laws.	To mitigate human encroachment as well as intensify awareness campaigns to expose people to the values and benefits of this important ecosystem.	Ghana Forest and Wildlife Policy Tema Metropolitan Assembly Bye- Laws
	Deforestation	While the planting of trees is been promoted and a bye-law to fine falling of trees is being enforced to mitigate wind storms.	The wetland plays a crucial role in regulating local climate, purifying water, controlling floods, and supporting livelihoods	

Gender	vulnerabilities arise from gender inequalities and socio-economic disparities, which are exacerbated climatic hazards	Relying on relief from NADMO. Furthermore, organizations such as NADMO and Fire Service have engaged in initiatives such as educating residents on flood preparedness, supplying relief items to assist flood victims, and conducting training on fire fighting.	Initiatives, including education on flood preparedness, relief provision for flood victims, and firefighting training, potentially reduce impacts to casualties and property damage during disasters, improving the community's ability to recover and rebuild after such events.	Medium Term Development Plan Tema Metropolitan Assembly Annual Action Plan National Gender Policy
	Women and vulnerable groups engaged in fish farming, may be exposed to smoke inhalation during the smoking process of fish, which is a common practice in the industry. Prolonged exposure to smoke can lead to respiratory problems and other health complications	Promoting gender mainstreaming into the Annual Action Plans Providing access to education and skills training for women, and strengthening legal frameworks to protect women's rights	Mainstreaming gender into the Annual Action Plan, alongside providing access to education and skills training for women, is assessed to foster greater gender equality, empower women economically, and promote social inclusivity within the metropolis.	
Water resources and water systems	The aftermath of flooding can result in persistent water quality issues.	Implementing post-flood water quality monitoring programs to assess contamination levels and identify potential health risks to affected communities. Improving sewage systems, wastewater treatment facilities, and stormwater management systems to reduce pollutants entering water bodies during floods.	Improving sewage systems, wastewater treatment facilities, and stormwater management systems reduces the influx of pollutants into water bodies during floods, thereby preserving water quality, ensuring public health,	Environmental Sanitation Policy Tema Metropolitan Assembly Annual Action Plan

C: List of Stakeholders

1. Ghana Education Service
2. EPA
3. Department of Agriculture
4. Farmer
5. Danish Embassy
6. Environmental and Health Service Unit
7. NADMO
8. Physical Planning Unit
9. Ghana National Fire Service
10. Ministry of Fisheries
11. Information Service Department
12. Gender Desk Office
13. Development Planning Unit
14. Ghana Water Company Limited
15. Obonu fm
16. Social, Personal and Health Education
17. Ghana Education Service
18. ABIBINSROMA FOUNDATION
19. Ghana Meteorological
20. Trader and Transport Association
21. Department of Horticulture
22. Department of Urban Roads
23. Chief Imam
24. Pastor
25. Livelihood Empowerment Against Poverty (LEAP) Beneficiary
26. Chemu Senior High School – Headmaster
27. Waste Management Department
28. Persons with disability – Association
29. Women In Agriculture Department
30. Health and Nutrition Office

