Adapting Together, Thriving Tomorrow

Impact Storylines & Climate Risk Narratives

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

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Document Information

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Acronyms

AEP	Annual Exceedance Probability
AR	Assessment Report of the IPCC (AR4 published 2007; AR5 published 2013-4; AR6 2021-2)
CCRA	Climate Change Risk Assessment
CMIP	Climate Model Intercomparison Project; CMIP5 was used in the IPCC AR5 and CMIP6 in the AR6
CORDEX	Coordinated Regional Downscaling Experiment
CRIDF	Climate Resilient Infrastructure Development Facility
CRN	Climate Risk Narratives
EPA	Environmental Protection Agency
GCF	Green Climate Fund
GHG	Greenhouse Gas
IPCC	Intergovernmental Panel on Climate Change
LE	Lower Extreme
MESTI	Ministry of Environment, Science, Technology and Innovation
MMDAs	Metropolitan, Municipal and District Assemblies
NAP	National Adaptation Plan
RCP	Representative Concentration Pathways
SOM	Self-Organising Map, an artificial intelligence technique used to analysis the CMIP ensembles
SSP	Shared Socioeconomic Pathways
STMA	Sekondi-Takoradi Metropolitan Assembly
TaMA	Tamale Metropolitan Assembly
UNEP	United Nations Environment Programme
UE	Upper Extreme

1. Introduction

1.1. Study Aims and Objectives

The Government of Ghana, through the Environmental Protection Agency (EPA), under the auspices of the Ministry of Environment, Science, Technology, and Innovation (MESTI), has successfully obtained a grant from the Green Climate Fund (GCF) for a three-year project to build capacity to advance National Adaptation Plan (NAP) process in Ghana. The United Nations Environment Programme (UNEP) is the Delivery Partner, supporting and overseeing the project implementation.

The project entitled **"Enhancing multi-sector planning and capacity for effective adaptation in Ghana"** is being implemented by a small project team headed by a National Coordinator. The NAP project seeks to support multi-sectoral, medium- to long-term adaptation planning and budgeting in Ghana and promote the integration of climate change adaptation issues into development planning processes and policies. Systems for developing and sharing climate risk and vulnerability information will be reinforced, and sustainable financing mechanisms for climate change adaptation initiatives are set to be developed. To support the objectives of the NAP program, Zutari consortium was appointed to be the technical service provider to support Producing Climate Change Scenarios and Risk Assessments for Ghana based on best available techniques and data that can be used as the basis for national and sub-national climate change adaptation planning.

Central to the preparation of effective Climate Change Risk Assessments (CCRAs) is the ability to understand the science behind the projections, manage the inherent uncertainty associated with them, analyse them using a variety of techniques and then communicate the risks clearly and concisely in an actionable format for decision makers and other non-technical stakeholders and users.

This work will support several national initiatives in Ghana, including the updated NAP. However, it must also be able to underpin the climate rationales necessary to secure international climate finance. This requires an understanding of the past and current climate impacts, the potential impact of future climate, with and without climate change, and the disaggregation of other changes that are occurring in the area covered by the risk assessment, so that the impact of climate change can be isolated, analysed and presented in the form of a robust and clear climate risk narrative for Ghana.

1.2. Document Purpose

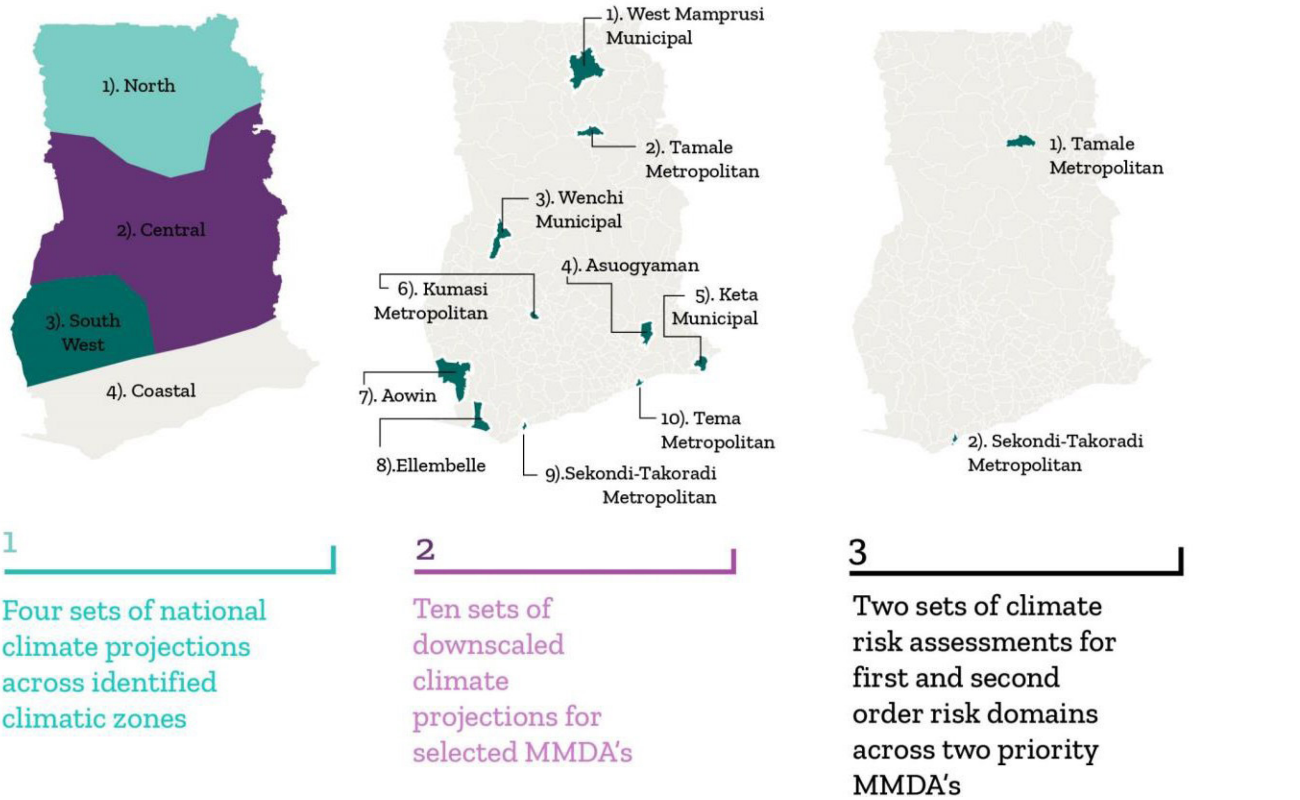
The specific activities to be undertaken under this work are as follows:

- Task 1: Develop a methodology for producing national climate change scenarios
- Task 2: Develop downscaled/area-based climate change projections for Ghana
- Task 3 & 4: Develop national and sub-national level climate risk assessments for two MMDAs
- Task 5: Summary for Policy Makers, Training and Capacity Building.

The identification of priority MMDAs followed a selection process developed in consultation with representatives of the Government of Ghana and with technical support from the UNEP (Figure 1).

This report is the deliverable from Task 3.2 of the Study and provides a set of ***Impact Storylines*** and the ***Climate Risk Narratives*** (or "stories of change") developed by gathering information on historical climate impacts experienced in Ghana considering how ecosystem function and other socio-economic stressors affected the impacts. Extreme event impacts were assessed according to the level of return period for specific climatic event and impact. This task considered the expected development pathways that can contribute to vulnerability, to be developed under the wider NAP project. This Document follows on from a previous Report that determined the most likely future climate scenarios for Ghana based on analysis using Plume Plots and Self Organising Maps (SOMs).

Figure 1 | Spatial scale of key deliverables



The purpose of the impact storylines and climate risk narratives is to identify the specific climate related risks, and the causal links, that should be evaluated and to present these in a simplified form. These impact storylines also help to confirm which are the relevant first and second order risk domains that require further investigations. These narratives are intended as discussion starters for engagement with stakeholders in order to ground truth the narratives in line with the local context.

The climate risk narratives (CRN) were developed for the critical climate change related risks at the National level, taking into consideration the four climate regions identified for Ghana in Task 2.1 and also for the two priority MMDAs selected for the further in-depth studies. This was done based on an initial assessment of the underlying social and economic conditions in the two MMDAs, the critical economic sectors and the anticipated climate related hazards, and after stakeholder engagements.

The approach to develop the CRN is summarized in **Section** Error! Reference source not found. of this Report and the data to support the climate risk narratives is included in **Appendix A.**

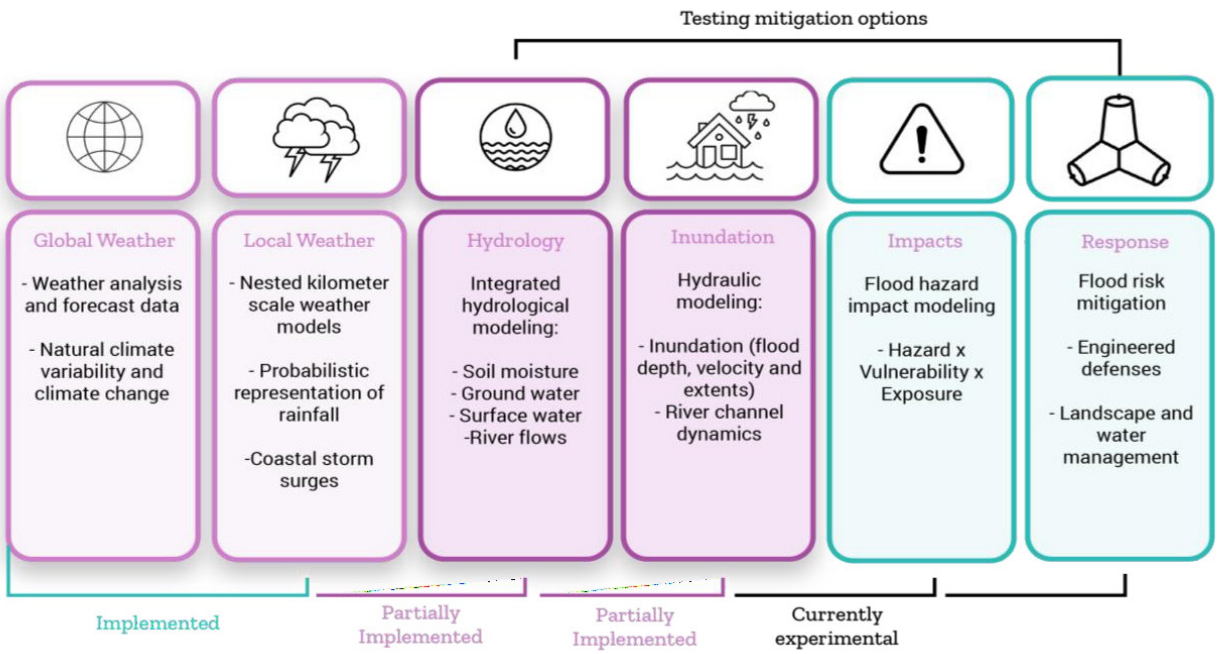
2. Overview of the Approach

The impact storylines and climate risk narratives are descriptions of the future climate, environment, economic activities and society under changed climate for a given location or region and a specific climate scenario. Such narratives constitute an integrative communications device that shows promise of being more effective than presenting technical maps of climate statistics and better suited to integrating into broader scenario development and planning processes. The narratives are also gender sensitive and consider how risks and vulnerability may impact women and men differently.

The use of event based, and impact storylines is also supported by the proposed approach to developing climate risk narratives based on the assessment of different climate models and scenarios. Individual storylines of potential impact were developed for each of the priority risk domains identified for the two priority MMDAs and these informed impacts modelling where possible.

The latest IPCC AR6 Report highlights the potential for event-based storylines to assess the potential risks associated with climate change particularly for high risk – low probability events, which are of particularly concern for disaster risk reduction. Event-based storylines allow for conditional explanations, without full attribution of every causal factor, which is crucial when some aspects of the latter are highly uncertain (e.g., due to unusual natural variability or limited process understanding). Event-based storylines go beyond attributing past events or their physical drivers and give the opportunity to explore plausible future events (Sillmann, et al., 2021). An example of such an event-based storyline is shown in the figure below which is a case study from modelling the risks associated with increased flooding in the United Kingdom and the testing of potential adaptation measures.

Figure 2 I Example of a climate risk modelling pathway for assessing climate related flood risks



Source: based on (Government of the United Kingdom, 2016)

As a communication tool, the climate scenario analysis forms the basis for developing the climate risk narratives (stories of change) and impact storylines, describing a range of future climates including various interactions between climate variables (e.g. temperature, wind, evaporation etc) and potential impacts. The narratives constitute an integrative communications device that shows promise of being more effective than technical maps of climate statistics and better suited to integrating into broader scenario development and planning processes. The CRN process is described in Jack *et al.*, 2020.

3. Climate Change Impact Storylines

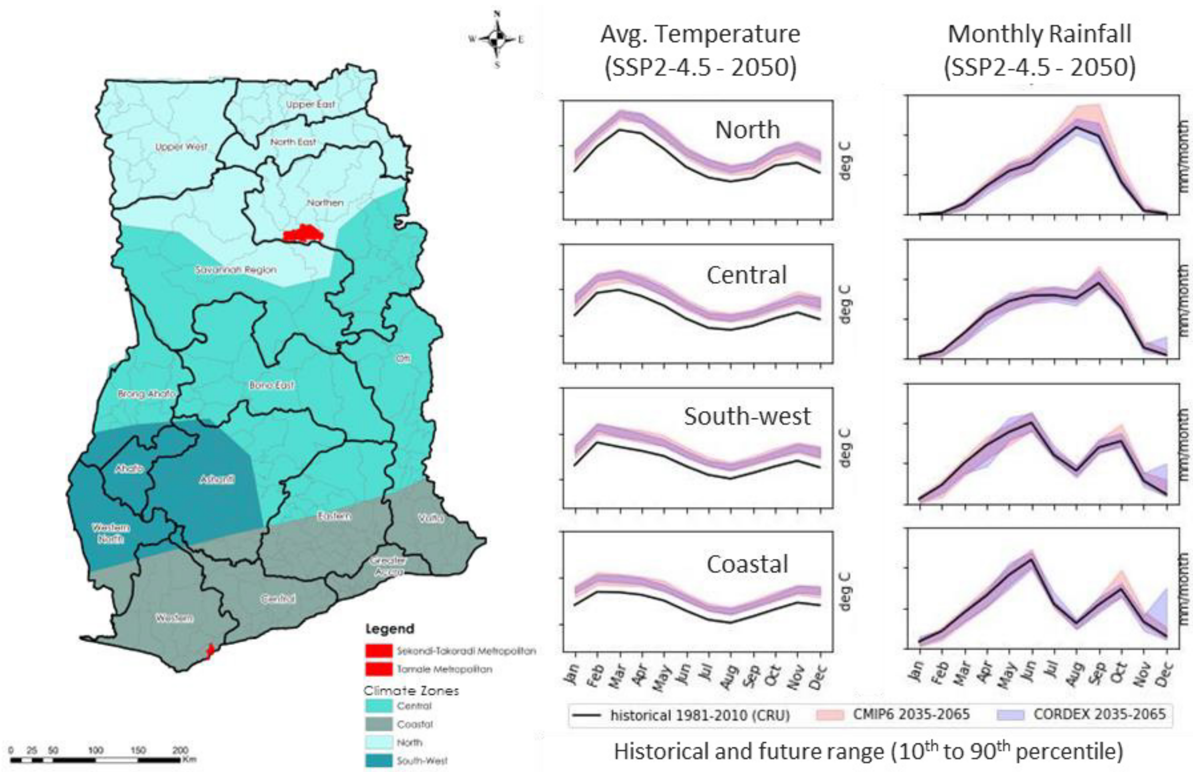
3.1. Summary Climate Risk Narratives for Ghana

Future Climate Scenarios

The overall messages about future climate in Ghana emerging from the analyses are as follows:

- **strong confidence of increases in air temperatures** manifested in all scenarios and for all four climate zones. Those increases amount to **0.5 to 1.5 °C**, **1.5 to 2.5 °C** and **2.5 to 4.5 °C** by the end of the century under **RCP26/SSP126, RCP45/SSP245 and RCP85/SSP585** respectively.
- **moderate to low confidence** message of **weak changes** (comparable to or only slightly stronger than the level of variability simulated for the past) in the overall **"wetness"** of the climate **without a clearly defined direction** of future changes in total annual rainfall, independently of emission scenario. That **low confidence** is partly caused by the lack of consistency in historical rainfall trends between observational data and model simulations. The latest CMIP6 climate models suggest greater sensitivity and potential increase in **"wetness"** in the North by 2050.
- Historical trends in **increasing frequency and magnitude of extreme events**, particularly with regards to **very hot days** and increasing **maximum daily rainfall** contributing to an increased **risk of flooding**, will likely continue, becoming more intense **with higher emission scenarios**.

Figure 3 I Summary of potential climate impacts by 2050 for the four homogeneous hydro-climatic zones



Key Sector Impacts

All sectors will be impacted by climate change with primary sectors such as agriculture, forestry and fisheries being the most sensitive and high risk. Poor and vulnerability communities will be most negatively impacted, with women particularly at risk from future climate change impacts. Water insecurity will increase mainly due to increasing demands, but also impacted by catchment degradation, sand-mining, increasing upstream demands and future developments. Climate change will not likely have significant impact on rainfall with a greater probability of slight increases in precipitation. Increasing temperature, however, will contribute to higher evaporation which could impact on water security. This will have the greatest impact on local water sources and will have less of an impact on larger and more integrated systems, A likely increase in extreme events contributing to flooding, wildfires, and landslides will increase the risk to infrastructure including roads, power lines, water treatment works, airports, and water supply pipelines. Flooding and coastal erosion will also threaten power stations, particularly located along the coast, and will have a negative impact on the fishing industry. Warmer sea temperatures and changes in ocean currents will also impact the fishing industry. Climate change will have a disproportional impact on more vulnerable communities and women across Ghana. Overall, an increase in very hot days will negatively impact on human health and livestock productivity. This will be greatest in the northern regions with less of an impact reduced temperature impacts closer to the coast.

Vulnerability

Vulnerability to climate change in Ghana is most pronounced for those who rely heavily on natural resources and have limited capacity to cope with these changes, especially those dependent on climate-sensitive livelihoods like agriculture. Smallholder farmers, particularly female-headed households, are highly exposed to the impacts of climate change and variability. Women constitute 52% of the agricultural labour force in Ghana and produce 70% of subsistence crops (Ministry of Foreign Affairs of the Netherlands, 2018). They also rely on water and crops for their household responsibilities. However, their adaptive capacity to climate change is constrained by factors such as limited access to financial resources, insufficient information and technology, and unfavourable land tenure systems.

Ghana's high vulnerability score and low readiness score place it in the upper-left quadrant of the ND-GAIN Matrix, indicating both a great need for investment and innovation to improve readiness and an urgency for action. Ranked as the 64th most vulnerable and the 124th most ready country, Ghana's heightened vulnerability can be attributed to factors such as reliance on agriculture, exposure to extreme weather events, and potential consequences of climate change on water resources, health, infrastructure, and ecosystems. The low readiness score emphasizes the challenges Ghana faces in resource mobilization, effective governance, and promoting social preparedness for climate adaptation.

The agriculture sector is considered to be the most vulnerable to the potential impacts of climate change. The vulnerability of this sector can be reduced through improved crop varieties, increased access to irrigation, improved access to markets, and the application of climate smart agriculture (CSA).

The rapid growth of urban areas in Ghana often results in an increase in people living in informal areas. These are often located in existing wetlands and flood plains which will be directly impacted by an increase in extreme rainfall. Poor urban planning, lack of maintenance, pollution, and environmental degradation are all contributing factors to increasing the climate change related risks across Ghana.

Adaptation Responses

The Ghanaian Government has been investing in integrating climate change objectives and priorities into sector-specific development plans in agriculture, transportation, and energy to mainstream climate change strategies and coordinate the strategic climate adaptation activities, in line with the country's socio-economic development objectives. In the Fourth National Communication, Ghana is particularly focused on increasing its resilience through the development of sustainable land use practices, climate-proof infrastructure, water security, energy security, sustainable forest management, and urban waste management. It is evident that there is a need to adapt to the future unpredictable climate. Investing in capacity building, and education on climate risks, as well the dissemination of information was found to be a crucial component for a successful climate change adaptation strategy for all sectors in Ghana.

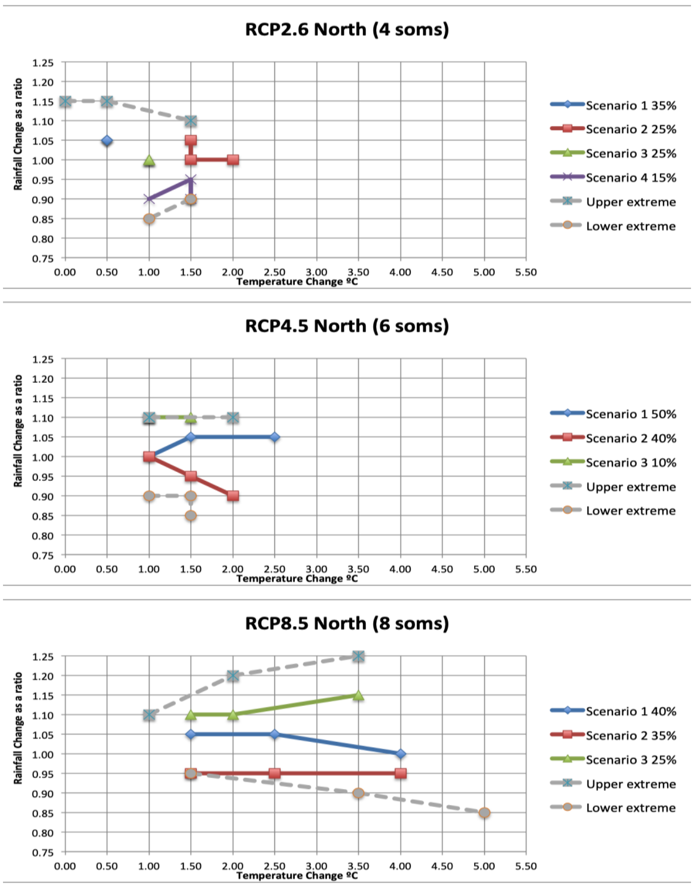
In addition to specific adaptation actions identified in key sectors such as agriculture, infrastructure and the built environment, Ghana should look to build on its general resilience to climate related impacts through a series of paradigm shifts including, amongst others, (1) scaling up climate smart agriculture (CSA) practices, (2) supporting the transition to more water sensitive cities (WSC), (3) investing in improved monitoring and early warning and disaster management systems, (4) investing in ecological infrastructure and ecosystem based adaptation (EbA), and (5) improved education, training and capacity building of key institutions and staff. Underlying these must be a priority focus on vulnerable economic sectors and communities, including women, and the leveraging of alternative funding options.

3.2. Tamale Metropolitan Assembly (TaMA)

3.2.1. Overview of Future Climate Scenarios

Future climate change projections for the Northern climate zone (Figure 4), in which Tamale MA is located show a risk of increasing temperatures even at lower GHG concentrations. Average annual temperature will increase by up to 2 ºC by mid-century, and will vary from 1.5 up to 4ºC, by the end of the century. Precipitation projections, in contrast, carry large uncertainties. There is a slightly greater chance of small increases rather than a similar level of decrease, of around +/- 5%. in mean annual precipitation by mid-century compared to the base years, although some scenarios do show a more significant potential for increase in mean annual precipitation. By the end of the century, either an increase or decrease in mean annual precipitation appears possible of around +/– 10% by 2100.

Figure 4 I Climate change pathways identified from the SOMs analysis for the Northern climate zone



Based on the resuts of the SOMs analysis we can identifed to different climate future as follows:

- **A warmer and drier climate** – represented by Scenario 2 under RCP4.5 – 40% likelihood
- **A hotter and wetter climate** – represtened by Scenario 3 under RCP8.5 – 25% likelihood.

Each of these climates is equaly possible and presents unique challenges that will require sound response measures to reduce the possible impacts of climate change. These are described below.

3.2.2. TaMA Climate Risk Narrative 1: Warmer and drier climate

Welcome to Tamale Metropolitan Assembly in Ghana. The year is 2053 and the changing climate has presented myriad challenges for the people of Tamale. With 10% less rain and average temperatures 2ºC warmer than in the past, droughts and sizzling heat waves are now part of the region's rhythm.

In this ever warming and dry city, health troubles like heatstroke and dehydration affect everyone, especially the elderly, outdoor workers, and children. Wealthier populations have opted for air conditioning, which only pushes electricity demand, adding more pressure on Tamale's already stretched energy network. Local water sources have run dry and crop yields are significantly less.

Decades ago, Tamale had a thriving farming industry. Sadly, those days are fading, and food security has become a pressing issue due to declining crop yields and scarce water resources. The city's population has been growing by 3.5% annually, adding to the water security risk. As water shortages grip the area, people find it increasingly difficult to access clean drinking water. Traditionally, women and girls bear the responsibility of water collection and household chores. This burden now weighs heavier than ever as they travel great distances to secure water for their families. Unfortunately, their health suffers, and education and income generation opportunities are slipping away.

Due to the impacts of catchment degradation, evaporation, pollution, and sand mining, water resources in Tamale are diminishing, making it challenging to access clean water. Additionally, rain is no longer sufficient to recharge aquifers for groundwater extraction. Nevertheless, Tamale remains committed to protecting its community and way of life by implementing climate and gender-sensitive plans to make businesses and communities less vulnerable to climate risks and help citizens adapt.

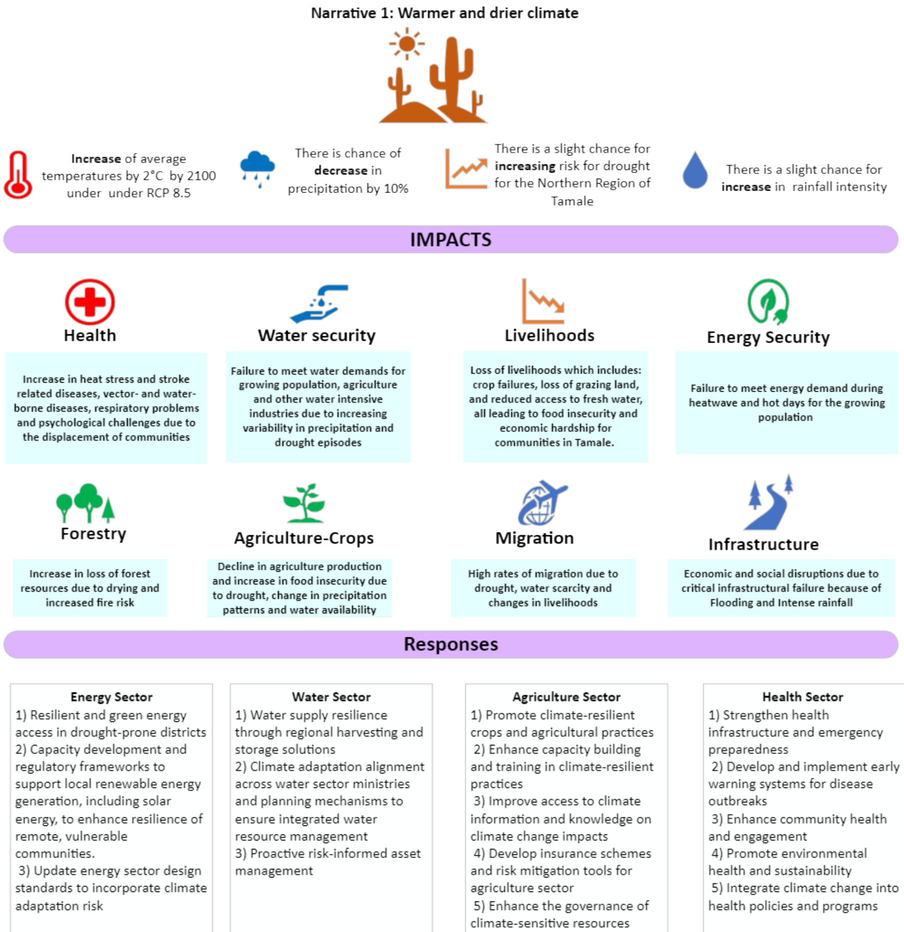
A particular focus for Tamale is on protecting critical water sources. This includes both the protection of local catchment area as well as addressing major concerns of sand-mining and catchment degradation in the White Volta, which is the major water supply source for the city. Furthermore, efforts to minimise the impact of increasing temperatures on heat stress in the city requires not only the design of more energy efficient houses, that are better insulated against the heat, but also efforts to protect and rehabilitate green spaces within the city, particularly the tress indigenous to the area.

Tamale stands at a turning point, with people from all walks of life joining hands to tackle the challenges of climate change. With determination and unwavering spirit, the people of Tamale are paving the way for a sustainable, inclusive, and resilient future, including investing in nature.

Figure 5 | Increasing water security and drought risks for Tamale Metropolitan Assembly

(Photo credit: acucircle.blogspot.co.uk) (Photo credit: savannanews.blogspot.com)

Figure 6 | Climate Risk Narrative for Tamale Metropolitan Assembly: Narrative 1 - Warmer and drier



3.2.3. TaMA Climate Risk Narrative 2: Hotter and wetter climate

The year is 2053, and the vibrant city of Tamale, Ghana's fourth largest metropolis, faces a challenging future. Climate change has redefined the region, with sweltering heat and torrential rains becoming the new norm. In this era, temperatures have soared by an astonishing 4°C, and annual precipitation has surged by 15%. Gone are the days when a once-in-a-century rainfall was a rarity; now, such events are

3.6 times more likely to occur, escalating the risk of catastrophic floods.

The citizens of Tamale confront a new reality, as the harsh conditions not only threaten their homes but also contribute to the spread of deadly diseases. The climate change trifecta of rising temperatures, increased precipitation, and elevated humidity has created the perfect storm for vector and water-borne illnesses. Mosquitos and ticks, thriving in these conditions, carry diseases like malaria and dengue fever, while stagnant water becomes a breeding ground for infectious agents.

Toxic algal blooms, too, have become a common occurrence, further endangering public health. This is as a result, not only of the hotter and wetter conditions, but also the failure to manage pollution and in particular poor sanitation. Amidst this turmoil, women, who have long faced marginalization in Tamale, bear the brunt of the consequences, their vulnerability intensified by the city's climate risks.

The situation is further complicated by Tamale's reliance on climate-sensitive industries, such as agriculture and trading, for its economic livelihood. High poverty levels leave communities with limited resources to adapt to these new and every changing conditions, making it crucial for the city to develop gender-sensitive strategies that prioritize women and other vulnerable groups.

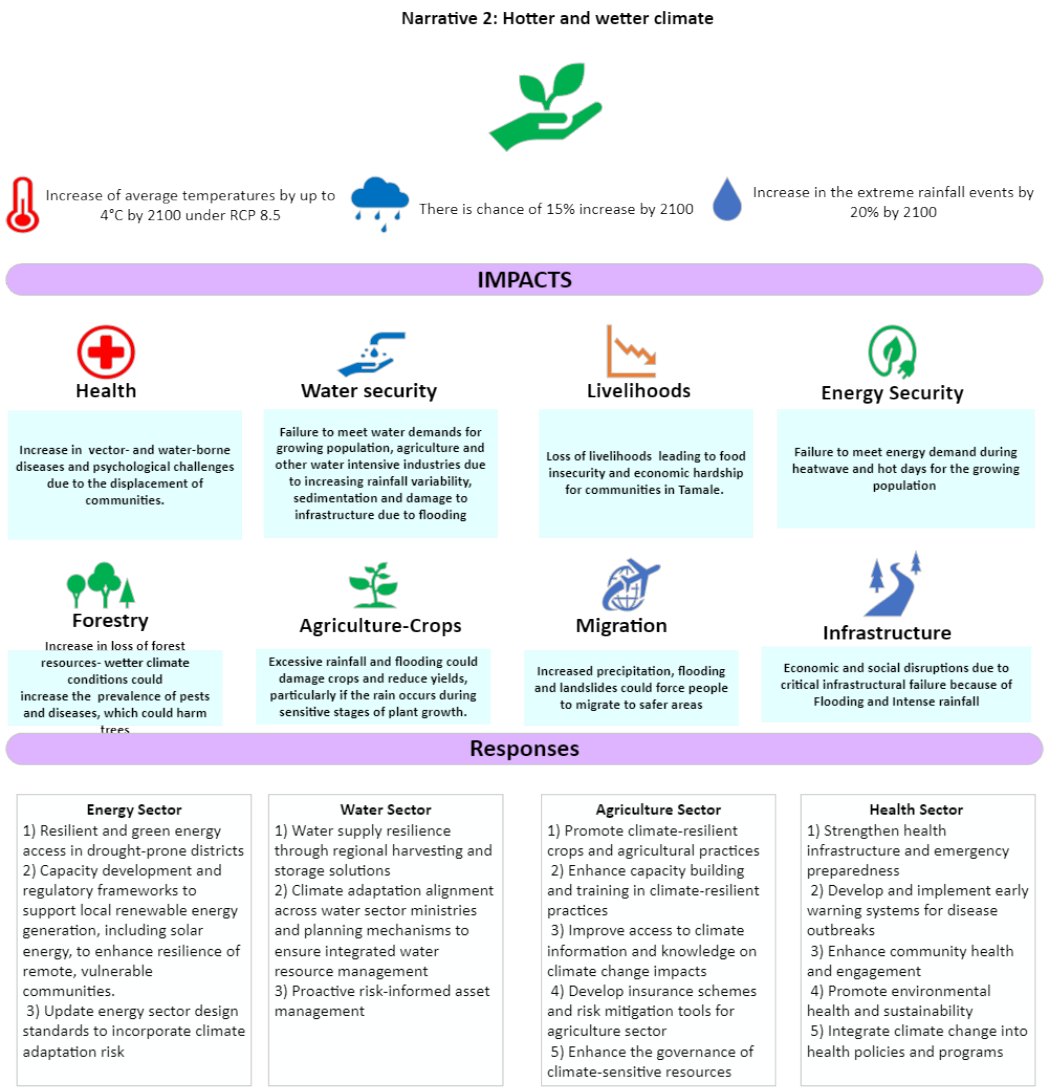
Faced with crumbling infrastructure and eroding landscapes, increasing flood risks, and soaring health costs, the people of Tamale continue to persevere, striving to build a future that is both resilient and inclusive. They recognize that, while the challenges are great, there is still hope and opportunity for change as they work together to navigate the uncertain waters of climate change.

Addressing the increasing flood risks is a priority requiring significant investments in improved urban drainage systems and flood early warning. It has also been recognised how important it is to invest in nature-based solutions as these help by absorbing some of the flood peaks and also help with cooling the city. The hotter and wetter climate makes it even more important to invest in sustainable sanitation and improved public health systems including better protection and access to critical health facilities.

Figure 7 | Aerial view of the affected houses in Tamale August 2021 (Photo: Geoffrey-Buta)

Source: https://www.ghanaiantimes.com.gh/5-hr-downpour-renders-tamale-sagnerigu-residents-homeless/

Figure 8 | Climate Risk Narrative for Tamale Metropolitan Assembly: Narrative 2 – Hotter and Wetter

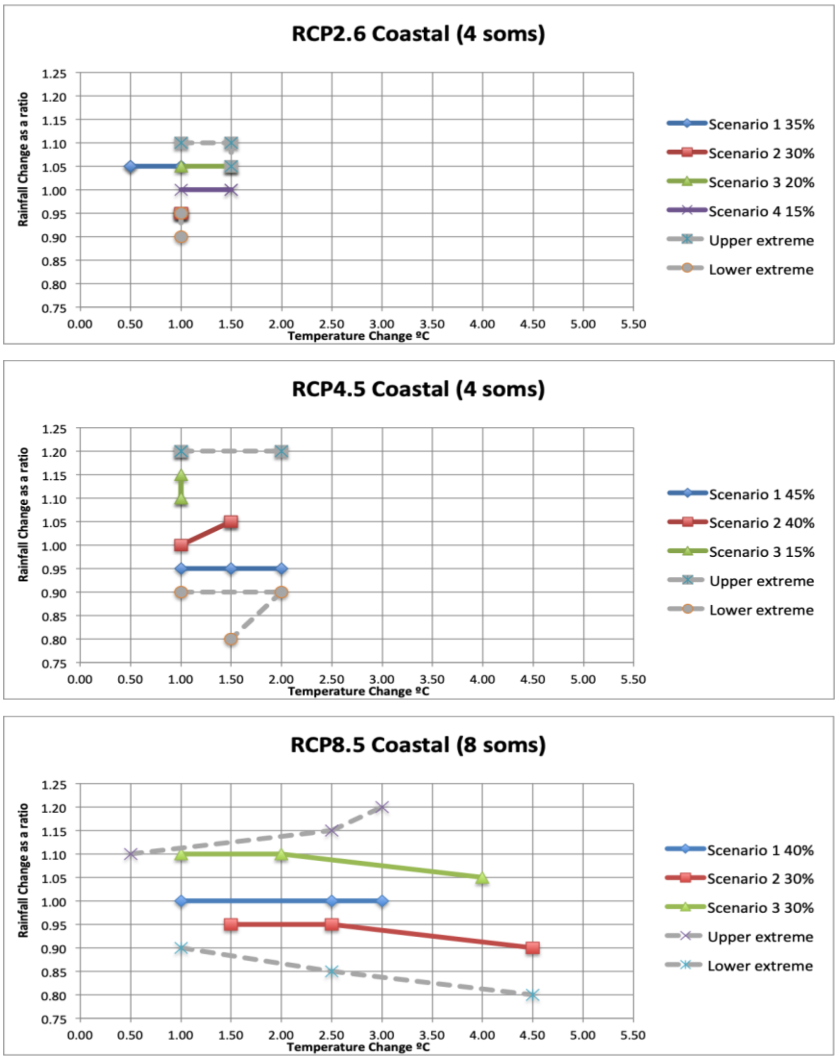


3.3. Sekondi-Takoradi Metropolitan Assembly

3.3.1. Overview of Future Climate Scenarios

Future climate change projections for the Coastal climate zone of Ghana (Figure 9), in which STMA is located, will likley see temperature increases of between 1.5 °C under RCP2.6 to 3 /4.5 °C under RCP8.5 with RCP4.5 suggesting a mid-point of about 2.0 °C increase by 2100. There is a roughly equal chance of small increases and decreases in annual average precipitation. Typically, around a 10% increase or 5% decrease in mean annual precipitation (MAP). Howeve the most likley scenario is of little to no change in MAP although there is still likley to be increased variability in rainfall. The most extremes scenarios suggest a possiblility of up to +/- 20% change in MAP, but that these have a very low probability. Even with little change in rainall, it is expected that there will be an increase in extreme rainfall leading to an increased flood risk particularly when combined with increasing sea levels.

Figure 9 | Climate change pathways identified from the SOMs analysis for the Coastal climate zone



Based on the resuts of the SOMs analysis we can identifed to different climate future as follows:

- **A warmer and drier climate** – represented by Scenario 1 under RCP4.5 – 45% likelihood
- **A hotter and wetter climate** – represtened by Scenario 3 under RCP8.5 – 30% likelihood.

Each of these climates is equaly possible and presents unique challenges that will require sound response measures to reduce the possible impacts of climate change. These are described below.

3.3.2. STMA Climate Risk Narrative 1: Warmer and drier climate

The residents of Sekondi-Takoradi Metropolitan Assembly, a coastal city in southern Ghana, reflect on life in the late 21st century, when early summer temperatures had only risen by a mere 1°C compared to the early 21st century. Back then, the effects of climate change were just beginning to manifest, and the city's inhabitants were yet to face the full extent of the challenges that lay ahead.

The year is now 2053, and Sekondi-Takoradi's people have endured decades of rapidly changing climate. Extreme climatic events like sea-level rise, flooding, and extreme heat have become more common, disrupting their daily lives. The once-thriving metropolis now grapples with escalating risks of infrastructural damage, loss of livelihoods, and community displacement and migration, with the most vulnerable groups, such as women and the elderly, bearing the brunt of these impacts.

Despite global efforts to mitigate climate impacts, temperatures in Sekondi-Takoradi have risen by around 1.5°C and mean annual precipitation has decreased by around 5%. The rising sea levels continue to exacerbate coastal impacts through coastal erosion, affecting various sectors such as fisheries, water resources, critical infrastructure, coastal ecosystems, health, and dry-land agriculture.

In a significantly dryer climate, water shortages have hit the local population hard, especially women and girls who shoulder the burden of fetching water for their families. It also impacts energy supply.

Reduced rainfall and increased evaporation, worsened by catchment degradation, sedimentation, and illegal sand-mining, have led to even scarcer water resources. The decline in agricultural productivity in the region has compelled people to abandon their homes in search of better opportunities.

Health issues have also become more prevalent as warmer and drier conditions lead to a rise in heat-related illnesses like heatstroke and dehydration, particularly among vulnerable groups. While these are not as intense as inland, coastal communities grapple with mental health challenges due to displacement and loss of livelihoods caused by flooding, erosion, and landslides. Water scarcity has heightened the risk of water-borne diseases, especially in areas without access to essential services.

Sekondi-Takoradi's vulnerability to climate change is amplified by its proximity to the sea, reliance on coastal resources, and extensive coastal and environmental degradation, including the loss of coastal mangroves. In response, the city has embraced climate and gender-sensitive, nature-based solutions. These initiatives aim to reduce the sensitivity of key economic sectors to climate risk and boost communities' adaptive capacity while prioritizing the needs of women and other vulnerable groups.

As the city looks ahead to 2100, Sekondi-Takoradi municipality remains steadfast in its commitment to protect and empower its people in the face of an uncertain future. The community is united in their determination to build resilience and ensure that everyone, regardless of age, gender, or socio-economic background, has the support and resources needed to thrive in a rapidly changing world.

The protection of critical infrastructure located on the coast and managing of coastal retreat in highly vulnerable areas has become a priority with rising sea levels. This also requires efforts to protect coastal resources as mangroves that have been affected by the pollution caused by the oil industry.

Figure 10 | Increasing water security and drought risks for Sekondi-Takoradi Metropolitan Assembly

Source: https://www.kyfilla.com/acute-water-shortage-hits-sekondi-takoradi/

Figure 11 | Degraded mangroves and wetlands

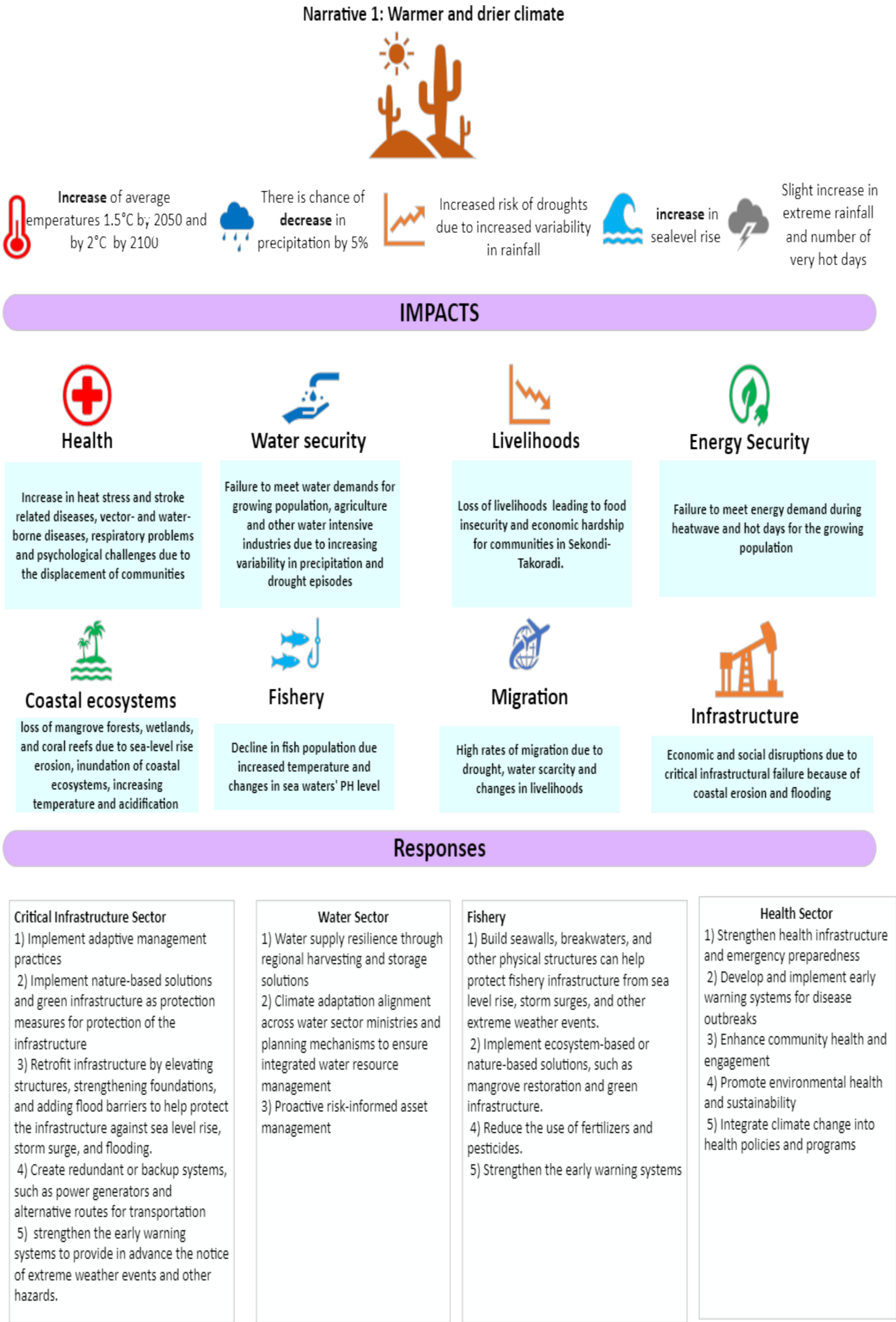
Source: **https://www.ghanaweb.com/**

Figure 12 | Coastal erosions risk for STMA (right)

Source: http://dx.doi.org/10.4314/just.v33i3.51[1]

1 Photograph credit G. F. A. Olympio and S. Amos-Abanyie, 2003

Figure 13 | Climate Risk Narrative for Sekondi-Takoradi MA: Narrative 1 - Warmer and drier



3.3.3. STMA Climate Risk Narrative 2: Hotter and wetter climate

The year is 2053, the bustling coastal city of Sekondi-Takoradi in Ghana faces the grim reality of a changing climate. With average temperatures soaring by 2°C, frequent torrential downpours, and encroaching sea levels, the city's infrastructure and livelihoods are increasingly threatened.

At the heart of the city, we follow the story of Ama, a strong-willed fisherwoman who is struggling to maintain her livelihood amid a decline in fish production and loss of revenue from the fishery industry. As a single mother, Ama is disproportionately affected by the climate crisis. The burden of managing her household, providing for her children, and ensuring their safety in a rapidly changing environment weighs heavily upon her. As a result, her health is beginning to suffer leading to further challenges.

Ama's days are filled with long hours of fishing, followed by managing the household chores, preparing meals, and caring for her children. The increased frequency and intensity of storms make it harder for her to secure a stable income, while the loss of coastal ecosystems affects the availability of fish. The added stress of declining fish stocks exacerbates the gender inequality in her community, as women like Ama struggle to maintain their traditional roles in the face of environmental upheaval.

In addition to the economic challenges, Ama is increasingly concerned about her children's health as the risk of vector and water-borne diseases, such as malaria and dengue fever, increases due to warmer temperatures and the presence of stagnant water. As a mother, Ama bears the additional responsibility of caring for her sick children, further straining her already limited resources.

Meanwhile, Kofi, an engineer working at the nearby coastal power plant, faces the constant threat of storm surges that could damage critical infrastructure, disrupt energy supply chains, and displace communities. Kofi is part of a team tasked with finding innovative solutions to protect the city's vital installations and prevent widespread power outages and damage to critical infrastructure.

As climate risks escalate, the people of Sekondi-Takoradi find themselves uniting to confront the mounting challenges. At the forefront of this movement is Mayor Adwoa Mensah, an unwavering advocate for climate action and resilience. She inspires her community, rallying a diverse coalition of individuals, including Ama and Kofi to join forces with Mayor Mensah to form a community task force dedicated to tackling these pressing issues. They recognize the need for climate and gender-sensitive, nature-based solutions that prioritize the needs of women and other vulnerable groups and are determined to convince the government that protecting natural systems and providing support for vulnerable communities is essential.

In their quest for a more resilient city, the task force members, led by Mayor Mensah, work closely with local authorities and international organizations to implement adaptive strategies. They advocate for the improvement of drainage systems, the development of sustainable infrastructure, and the implementation of land use policies that take climate risks into account. Under Mayor Mensah's guidance, the task force also champions women's empowerment and supports initiatives that help women like Ama and her family adapt to the challenges of climate change. Through their collaborative efforts, Mayor Mensah and the task force work tirelessly to lead Sekondi-Takoradi into a more climate-resilient future.

Through Mayor Mensah, Ama and Kofi's eyes, we witness the struggle and determination of a city to adapt to the new climate reality. Their story becomes a testament to the power of unity, innovation, and resilience in the face of overwhelming challenges while highlighting women's unique and disproportionate burdens amidst the climate crisis.

As Sekondi-Takoradi's future hangs in the balance, will the city be able to overcome the stormy days ahead, or will it succumb to the relentless forces of climate change? The fate of women like Ama rests on finding solutions that address all residents' needs as they navigate the uncharted waters of a changing world.

Figure 14 | Increased coastal and urban flooding risks for Sekondi-Takoradi

https://www.ghanaweb.com/ *https://newsghana.com.gh/*

Figure 15 | Local initiative aimed at dealing with sea erosion at Turtle Cove (Sekondi)

Source: https://www.purkh.com/articles/morphological-classification-and-protection-of-the-central-coastline-implications-for-coastal-erosion-management-in-ghan.pdf[2]

2 Ishmael Yaw Dadson1,Kofi Adu-Boahen1andBenjaminKofi Nyarko, 2018

Figure 16 | Location of Takoradi Power Plan showing exposure to sea level risk and storm surges

Source: Image from Ghana Forestry Commission (2021)

Figure 17 I Climate Risk Narrative for Sekondi-Takoradi MA: Narrative 2 Hotter and Wetter

Narrative 2: Hotter and wetter climate

Increase of average temperatures 2°C by 2050 and by 4°C by 2100

There is chance of **Increase** in precipitation by 10%

increase in sealevel rise by about 0.4m under RCP 4.5

Slight increase in extreme rainfall and number of very hot days

IMPACTS

Health

Increase in heat stress and stroke related diseases, vector- and water-borne diseases, respiratory problems and psychological challenges due to the displacement of communities

Water security

Failure to meet water demands for growing population, agriculture and other water intensive industries due to increasing variability in precipitation, damage to infrastructure, siltation and floods

Livelihoods

Loss of livelihoods leading to food insecurity and economic hardship for communities in Sekondi-Takoradi.

Energy Security

Damage to energy infrastructure that is in close proximity to the sea due to storm surges, extreme rainfall, flooding, causing power outages and disruptions in the energy supply chain

Coastal ecosystems

loss of mangrove forests, wetlands, and coral reefs due to sea-level rise coastal flooding and erosion, inundation of coastal ecosystems, increasing temperature and acidification

Fishery

Decline in fish population due more frequent and severe flooding, causing damage to coastal infrastructure and coastal habitats and loss of the coastal ecosystems

Migration

High rates of migration due to sealevel rise coastal flooding and erosion, water scarcity and changes in livelihoods

Infrastructure

Economic and social disruptions due to critical infrastructural failure because of coastal erosion and flooding

Responses

Critical Infrastructure Sector

1) Implement adaptive management practices
2) Implement nature-based solutions and green infrastructure as protection measures for protection of the infrastructure
3) Retrofit infrastructure by elevating structures, strengthening foundations, and adding flood barriers to help protect the infrastructure against sea level rise, storm surge, and flooding.
4) Create redundant or backup systems, such as power generators and alternative routes for transportation
5) strengthen the early warning systems to provide in advance the notice of extreme weather events and other hazards.

Water Sector

1) Water supply resilience through regional harvesting and storage solutions
2) Climate adaptation alignment across water sector ministries and planning mechanisms to ensure integrated water resource management
3) Proactive risk-informed asset management

Fishery

1) Build seawalls, breakwaters, and other physical structures can help protect fishery infrastructure from sea level rise, storm surges, and other extreme weather events.
2) Implement ecosystem-based or nature-based solutions, such as mangrove restoration and green infrastructure.
4) Reduce the use of fertilizers and pesticides.
5) Strengthen the early warning systems

Health Sector

1) Strengthen health infrastructure and emergency preparedness
2) Develop and implement early warning systems for disease outbreaks
3) Enhance community health and engagement
4) Promote environmental health and sustainability
5) Integrate climate change into health policies and programs

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Appendix A I Supporting Evidence for Climate Risk Narratives

A1 I Summary of Downscaled Climate Scenarios for TaMA

The expected change in critical climate variables for each of the selected climate scenarios and models for the different emission scenarios is shown in Table 1. The expected likelihood of the scenarios for the Northern Climate Zone was included in the table based on the results of the SOMs analysis.[3]

The two scenarios representing the selected climate risk narratives are highlighted in bold.

Table 1 I Range of potential change in critical climate variables for TaMA relative to the base period for the representative climate models representing the different future climate scenarios (CMIP5)

Period		2030-2040						2050-2060						2070-2080					
Climate Model		A	B	C	D	LE	UE	A	B	C	D	LE	UE	A	B	C	D	LE	UE
Climate variable	Baseline 1960-2000																		
RCP 2.6																			
Likelihood*		35%	25%	25%	15%	(A)	(A)	35%	25%	25%	15%	(A)	(A)	35%	25%	25%	15%	(A)	(A)
TG	27.6	2%	4%	4%	4%	4%	3%	1%	5%	4%	4%	4%	5%	3%	6%	3%	3%	4%	5%
TXx	36.3	1%	3%	3%	3%	3%	2%	1%	4%	4%	4%	3%	4%	2%	5%	2%	2%	4%	4%
SU30	29	-1%	5%	7%	7%	10%	2%	-1%	7%	7%	7%	12%	5%	1%	7%	4%	4%	11%	4%
PRCP-TOT	87	-2%	7%	-6%	-6%	-3%	9%	-4%	8%	0%	0%	-6%	12%	-6%	4%	8%	8%	-7%	6%
Rx1day	13	-36%	140%	-7%	-7%	-39%	56%	-22%	141%	37%	37%	-44%	179%	-17%	114%	224%	224%	-25%	115%
RCP 4.5																			
Likelihood*		50%	✗	**40%**	10%	(A)	(A)	50%	✗	40%	10%	(A)	(A)	50%	✗	**40%**	10%	(A)	(A)
TG	27.6	2%	✗	**4%**	4%	4%	3%	1%	✗	**4%**	4%	4%	5%	3%	✗	**3%**	3%	4%	5%
TXx	36.3	3%	✗	**3%**	3%	6%	3%	3%	✗	4%	6%	8%	6%	6%	✗	**5%**	6%	7%	6%
SU30	29	6%	✗	**1%**	11%	21%	11%	8%	✗	2%	18%	24%	18%	10%	✗	**3%**	18%	24%	18%
PRCP-TOT	87	-1%	✗	**-1%**	-13%	-21%	-13%	-1%	✗	-8%	-16%	-14%	-16%	-5%	✗	**0%**	-9%	-15%	-9%
Rx1day	13	4%	✗	**-43%**	-166%	-60%	- 166%	6%	✗	25%	-80%	-13%	-80%	-44%	✗	**1%**	60%	3%	60%
RCP 8.5																			
Likelihood*		40%	35%	✗	**25%**	(A)	(A)	40%	35%	✗	25%	(A)	(A)	40%	35%	✗	**25%**	(A)	(A)
TG	27.6	3%	4%	✗	**5%**	5%	3%	4%	8%	✗	8%	10%	4%	9%	12%	✗	**12%**	15%	9%
TXx	36.3	2%	3%	✗	**3%**	4%	2%	3%	6%	✗	5%	9%	3%	7%	10%	✗	**8%**	14%	7%
SU30	29	0%	12%	✗	**8%**	7%	0%	-1%	16%	✗	10%	12%	-1%	1%	20%	✗	**15%**	15%	1%
PRCP-TOT	87	-1%	-7%	✗	**6%**	27%	-1%	7%	-5%	✗	22%	8%	7%	0%	-3%	✗	**6%**	-8%	0%
Rx1day	13	100%	-81%	✗	**78%**	288%	100%	108%	60%	✗	120%	219%	108%	20%	22%	✗	**70%**	30%	20%

* *Likelihood of Individual Scenarios for the Northern Climate Zone, based on the SOMs analysis

TG - Daily Mean Temperature; TXx - Maximum temperature; SU30 - Hot days with a maximum above 30ºC (SU30), PRCPTOT - Total Annual Precipitation; Rx1day - Maximum 1-day total precipitation

Source: Selected models from CORDEX data (CMIP5)

3 For more detail on the analysis of future climate change scenarios refer to the Climate Scenarios Report.

In general, the latest **CMIP 6 model results (**Table 2**)** suggest **greater climate sensitivity** and the potential for more **significant "wetting"**, particularly over the Northern climate zone, but **further analysis is required** to clarify these results. Temperature is expected to increase significantly for Tamale with the greatest increases in temperature as a result of the higher global emission scenarios.

The results represent the 90th (Q90), 50th (Q50) and 10th (Q10) percentile results.

Table 2 I Range of potential change in critical climate variables for TaMA relative to the base period for the different future climate scenarios (CMIP6)

Period		**2030-2040**			**2050-2060**			**2070-2080**		
Climate variable	Baseline 1960-2000	**Q90**	**Q50**	**Q10**	**Q90**	**Q50**	**Q10**	**Q90**	**Q50**	**Q10**
RCP 2.6										
TG	27.6	3%	4%	6%	3%	4%	8%	3%	4%	8%
TXx	36.3	1%	3%	5%	2%	4%	7%	2%	4%	7%
SU30	29	2%	4%	13%	2%	6%	16%	2%	6%	15%
PRCP-TOT	87	-4%	5%	18%	-1%	7%	21%	-5%	6%	18%
Rx1day	13	-46%	44%	200%	-18%	44%	190%	-27%	46%	171%
RCP 4.5										
TG	27.6	2%	3%	5%	4%	5%	9%	5%	7%	11%
TXx	36.3	1%	3%	5%	2%	4%	7%	3%	6%	9%
SU30	29	0%	4%	12%	2%	7%	22%	4%	8%	27%
PRCP-TOT	87	-1%	9%	23%	-4%	10%	25%	-10%	10%	30%
Rx1day	13	16%	59%	218%	-33%	109%	240%	2%	140%	249%
RCP 8.5										
TG	27.6	2%	4%	6%	4%	7%	11%	7%	12%	18%
TXx	36.3	1%	3%	5%	2%	6%	10%	3%	10%	14%
SU30	29	0%	4%	13%	3%	6%	26%	3%	11%	31%
PRCP-TOT	87	-1%	11%	26%	0%	11%	36%	-6%	11%	46%
Rx1day	13	15%	107%	262%	23%	160%	342%	12%	190%	538%

TG - Daily Mean Temperature; TXx - Maximum temperature; SU30 - Hot days with a maximum above 30ºC (SU30), PRCPTOT - Total Annual Precipitation; Rx1day - Maximum 1-day total precipitation

Source: Data extracted from Climate Change Knowledge Portal

Table 3 I Expected change in Annual Exceedance Probability (AEP) for Design Rainfall events for the Northern Region in Ghana by 2050 under different global emission scenarios from CMIP6

Change in Annual Exceedance Probability, 2035-2064 (centre 2050) (change factor for occurrence/ year)						
	10-yr			**100-yr**		
Event	**10th**	**median**	**90th**	**10th**	**median**	**90th**
SSP1-1.9	0.82	1.55	2.32	0.67	1.95	3.58
SSP1-2.6	0.9	1.56	2.48	0.78	1.93	4.22
SSP2-4.5	0.95	1.8	3.06	0.96	2.47	5.77
SSP3-7.0	1	1.87	3.27	0.91	2.65	6.41
SSP5-8.5	1	2.32	5.15	0.99	3.58	13.05

Source: Climate Change Knowledge Portal

A2 I Summary of Downscaled Climate Scenarios for STMA

The expected change in critical climate variables for each of the selected climate scenarios and models for the different emission scenarios is shown in Table 4. The expected likelihood of the scenarios for the Coastal Climate Zone was included in the table. This is based on Self Organising Maps (SOM) analysis[4].

Table 4 I Range of potential change in critical climate variables for STMA relative to the base period for the representative climate models representing the different future climate scenarios (CMIP5)

Period		2030-2040						2050-2060						2070-2080					
Climate Model		A	B	C	D	LE	UE	A	B	C	D	LE	UE	A	B	C	D	LE	UE
Climate variable	Baseline 1960-2000																		
RCP 2.6																			
Likelihood of Individual Scenarios		35%	20%	15%	30%	(A)	(B)	35%	20%	15%	30%	(A)	(B)	35%	20%	15%	30%	(A)	(B)
TG	27.0	2%	4%	3%	3%	4%	3%	2%	5%	3%	3%	3%	5%	2%	5%	3%	3%	3%	5%
TXx	29.3	2%	4%	3%	3%	3%	3%	2%	5%	3%	3%	3%	5%	2%	5%	3%	3%	2%	5%
SU30	1	124%	254%	295%	295%	225%	238%	76%	306%	290%	290%	184%	294%	146%	261%	271%	271%	104%	306%
PRCP-TOT	94	11%	10%	18%	18%	-17%	9%	11%	24%	9%	9%	2%	17%	-7%	9%	3%	3%	3%	3%
Rx1day	12	30%	154%	172%	172%	-113%	44%	68%	222%	128%	128%	39%	172%	29%	104%	54%	54%	33%	62%
RCP 4.5																			
Likelihood of Individual Scenarios		✗	40%	**45%**	15%	(A)	(A)	✗	40%	45%	15%	(A)	(A)	✗	40%	**45%**	15%	(A)	(A)
TG	27.0	✗	3%	3%	3%	4%	3%	✗	4%	4%	4%	5%	4%	✗	5%	5%	5%	5%	5%
TXx	29.3	✗	2%	2%	2%	4%	2%	✗	3%	3%	4%	5%	4%	✗	4%	4%	4%	5%	4%
SU30	1	✗	111%	111%	9%	193%	9%	✗	112%	112%	24%	259%	24%	✗	206%	206%	84%	303%	84%
PRCP-TOT	94	✗	8%	8%	5%	0%	5%	✗	3%	3%	22%	5%	22%	✗	15%	15%	21%	9%	21%
Rx1day	12	✗	-48%	-48%	-48%	-77%	-48%	✗	-125%	-125%	124%	-63%	124%	✗	30%	30%	217%	-51%	217%
RCP 8.5																			
Likelihood of Individual Scenarios		30%	**30%**	40%	✗	(A)	(A)	30%	30%	40%	✗	(A)	(A)	30%	**30%**	40%	✗	(A)	(A)
TG	27.0	3%	**4%**	4%	✗	5%	3%	5%	6%	7%	✗	9%	5%	7%	**9%**	10%	✗	12%	7%
TXx	29.3	2%	**3%**	5%	✗	5%	2%	4%	5%	8%	✗	8%	4%	6%	**8%**	10%	✗	11%	6%
SU30	1	136%	**321%**	274%	✗	252%	136%	211%	487%	490%	✗	398%	211%	331%	**663%**	621%	✗	580%	331%
PRCP-TOT	94	-8%	**8%**	2%	✗	-9%	-8%	-4%	8%	10%	✗	7%	-4%	-9%	**11%**	26%	✗	-9%	-9%
Rx1day	12	-101%	**84%**	24%	✗	-21%	-101%	52%	101%	134%	✗	228%	52%	32%	**145%**	169%	✗	60%	32%

* *Likelihood of Individual Scenarios for the Northern Climate Zone, based on the SOMs analysis

TG - Daily Mean Temperature; TXx - Maximum temperature; SU30 - Hot days with a maximum above 30ºC (SU30), PRCPTOT - Total Annual Precipitation; Rx1day - Maximum 1-day total precipitation

Source: Selected models from CORDEX data (CMIP5)

4 For more detail on the analysis of future climate change scenarios refer to the Climate Scenarios Report.

In general, precipitation remains highly variable with the latest **CMIP 6 model results (**Table 5**). Most models** suggest the potential for more **wetting by the end of the century** over the coastal climate zone, but **further analysis is required** to clarify these results. Temperature is expected to increase for Sekondi-Takoradi with the greatest increases in temperature for the higher emission scenarios.

Table 5 l Range of potential change in critical climate variables for STMA relative to the base period for the different future climate scenarios (CMIP6)

Period		**2030-2040**			**2050-2060**			**2070-2080**		
Climate variable	Baseline 1960-2000	**Q90**	**Q50**	**Q10**	*Q90*	*Q50*	*Q10*	**Q90**	**Q50**	**Q10**
RCP 2.6										
TG	27.0	2%	3%	5%	3%	4%	7%	3%	4%	7%
TXx	29.3	2%	3%	5%	*2%*	*4%*	*6%*	3%	4%	7%
SU30	1	126%	271%	475%	*189%*	*401%*	*670%*	206%	447%	741%
PRCP-TOT	94	-12%	-1%	7%	*-8%*	*-2%*	*6%*	-9%	0%	11%
Rx1day	12	-55%	25%	97%	*-74%*	*-12%*	*82%*	-28%	44%	114%
RCP 4.5										
TG	27.0	2%	3%	4%	4%	5%	7%	5%	7%	9%
TXx	29.3	2%	3%	4%	*3%*	*5%*	*7%*	4%	6%	8%
SU30	1	86%	223%	455%	*228%*	*361%*	*676%*	279%	602%	889%
PRCP-TOT	94	-9%	-1%	4%	*-10%*	*-1%*	*9%*	-15%	0%	10%
Rx1day	12	-26%	37%	114%	*-63%*	*39%*	*149%*	-27%	47%	147%
RCP 8.5										
TG	27.0	2%	3%	5%	4%	7%	9%	6%	10%	14%
TXx	29.3	2%	3%	5%	*3%*	*6%*	*8%*	4%	9%	13%
SU30	1	78%	221%	501%	*228%*	*544%*	*871%*	397%	957%	1287%
PRCP-TOT	94	-14%	-2%	8%	*-21%*	*-5%*	*6%*	-24%	-9%	15%
Rx1day	12	-90%	40%	115%	*-47%*	*63%*	*161%*	-74%	77%	188%

TG - Daily Mean Temperature; TXx - Maximum temperature; SU30 - Hot days with a maximum above 30ºC (SU30), PRCPTOT - Total Annual Precipitation; Rx1day - Maximum 1-day total precipitation

Source: Data extracted from Climate Change Knowledge Portal

Table 6 l Expected change in Annual Exceedance Probability (AEP) for Design Rainfall events for the Western Region in Ghana by 2050 under different global emission scenarios from CMIP6

Change in Annual Exceedance Probability, 2035-2064 (centre 2050) (change factor for occurrence/ year)						
	10-yr			**100-yr**		
Event	**10th**	**median**	**90th**	**10th**	**median**	**90th**
SSP1-1.9	0.92	1.38	1.87	0.85	1.72	3.18
SSP1-2.6	0.75	1.3	1.93	0.61	1.56	3.39
SSP2-4.5	0.84	1.45	2.53	0.72	1.99	4.13
SSP3-7.0	0.91	1.73	2.66	0.67	2.4	5.68
SSP5-8.5	0.93	1.72	2.79	0.87	2.3	5.29

Source: Climate Change Knowledge Portal